SEVENTY-FIFTH ANNIVERSARY NUMBER

SCIENTIFIC AMERICAN

A Weekly Review of Progress in

INDUSTRY · SCIENCE · INVENTION · MECHANICS

THE MATERIALIZED DREAM OF SEVENTY-FIVE YEARS OF PROGRESS

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OWNERS' FAITH
in
WHITE TRUCKS

THE following list of large investments in White fleets shows the faith large truck owners have in White equipment.

2 owners have invested over	**$2,000,000**		
4 owners have invested between	**1,000,000**	**and**	**$2,000,000**
5 owners have invested between	**500,000**	**and**	**1,000,000**
22 owners have invested between	**250,000**	**and**	**500,000**
82 owners have invested between	**100,000**	**and**	**250,000**

Experienced truck users *know* truck value in terms of earning power, through actual performance of one truck against another.

They *know* that White Trucks do the most work for the least money, and they back that knowledge by increasing their investments year after year.

The purchaser of one or a few trucks can safely follow their example.

THE WHITE COMPANY
CLEVELAND

IN the bearings sponsored by **SKF** its type of anti-friction bearings have been developed to their highest perfection. And **SKF** further provides an engineering service not only to assure to itself proper application and use of **SKF** marked products but to help the buyer to fully capitalize the mechanical value built into each device. This service is freely offered and is being continually broadened and advanced by laboratory research that is international in scope. You are assured a similar service behind every product bearing the mark—

SKF

Among these products now offered are:

Single row deep grove ball bearings
Double row self-aligning ball bearings
Steel balls
Transmission equipment

SKF Industries, Inc.
165 Broadway, New York City

Supervising at the request of the stockholders

The Hess-Bright Manufacturing Co.
SKF Ball Bearing Co.
Atlas Ball Co.
Hubbard Machine Co.
SKF Research Laboratories

SKF *Research Laboratories established at Philadelphia to co-operate with the big Gothenburg Laboratories in the study of the American Manufacturers' friction problems.*

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THE SCIENTIFIC AMERICAN, October 2, 1920. Volume 123, Number 14. Published weekly by Scientific American Publishing Company at 233 Broadway, New York. N. Y. Subscription price $6.00 per year. Entered as second-class matter June 18, 1879, at the post office at New York, N. Y., under the act of March 3, 1879.

Announcing Packard "Single Six"

The 10-Year Car

WE have always made large cars designed for maximum speed, great power, and all the roominess that goes with a long wheelbase. The ultimate development has been the Twin Six, which has firmly established itself in the regard of the public, and which we have been producing and marketing for a number of years.

Packard reputation for motor cars rests solidly upon the *Twin Six*, and it always will!

Packard

But there has for years been an insistent demand for another car to supplement the Twin Six: a car of shorter wheelbase and lighter weight, a general-purpose car of great maneuverability in traffic, one that would park in a short space at the curb.

And the demand was that this light car should give unusual gasoline mileage and tire mileage, and finally, that it should be designed and built Packard-wise, and therefore be able to keep out of the repair shop longest and to require least attention from its owner or driver.

We thought it over and studied the problem for a good many years, during all of which we were accumulating experience in the design and production of the highest possible grade of car.

We have at various times during the past ten years designed a light-weight companion to our larger cars, but were never entirely satisfied with our efforts.

Then the war broke out in 1914, and believing that America would inevitably become involved, we turned our attention to designing airplane engines, and from then to the close of the war had a thoroughly successful experience in designing and manufacturing airplane motors, which, as you know, must give the greatest power with the least possible weight.

* * *

We learned a great deal through this experience that was applicable to the automobile, and towards the close of the war we felt we were finally well equipped by experience to design the light-weight car.

Meanwhile, with a constantly growing talk of congestion in traffic, and increasing cost of gasoline, tires and other supplies, the demand for the light car became more and more insistent.

* * *

We have taken several years for the development and perfection of this new Packard, but we believe we have accomplished what we set out to do, and take now a pride in announcing that the Packard Single Six will soon be ready. It will be manufactured alongside the Twin Six and by the same matured and experienced organization.

The new car is of five-passenger capacity and will be offered in Touring, Runabout, Coupé and Brougham or Sedan.

The motor has six cylinders, 3⅜" bore by 4½" stroke. It is therefore of medium size, and despite its light weight is very sturdily built.

It is equipped with the Fuelizer.

The *Single Six* motor is new throughout, but it is not experimental.

It includes every principle of good engineering that our experience has shown to make for maximum power, coupled with silent operation and freedom from annoying troubles. We have failed of our intentions if we have not produced a motor that will run longer and require less attention than any other.

Our chassis design is very simple and clean. Its light weight, together with its unusually efficient motor, result in a very economical car.

As an instance of this, in our test driving in cross-country runs, we have made over twenty miles to the gallon of gasoline. Of course, in congested city driving, the mileage will not be so high.

Average tire mileage can be expected to exceed 15,000 miles. In our extensive experimental driving of this new car, we have had some tires in fair condition at the end of 25,000 miles.

It is an agreeable car to operate, having the easiest possible steering, the lightest clutch action, the shortest turning radius and, we believe, all those qualities that you would like to have in a light-weight car for general purposes.

The workmanship and finish are Packard throughout.

Packard

The greatest obtainable luxury, the maximum power, and the ultimate in road-ability, must always be found in the large car. That is the field in which the Packard Twin Six will always be dominant.

In this new car we have not attempted to compete in that field, but rather to produce an active, easily-operated, high-grade, light car, with all the elements of efficiency, economy of operation and, above all, long life.

There are Packard cars today, designed years ago, that are nearing the half-million mark in miles traveled.

The new Single Six is also, we confidently believe, a TEN-YEAR CAR.

The price of the Touring Car is $3640 at Detroit.

PACKARD MOTOR CAR COMPANY, *Detroit*

SEVENTY-SIXTH YEAR

SCIENTIFIC AMERICAN

THE WEEKLY JOURNAL OF PRACTICAL INFORMATION

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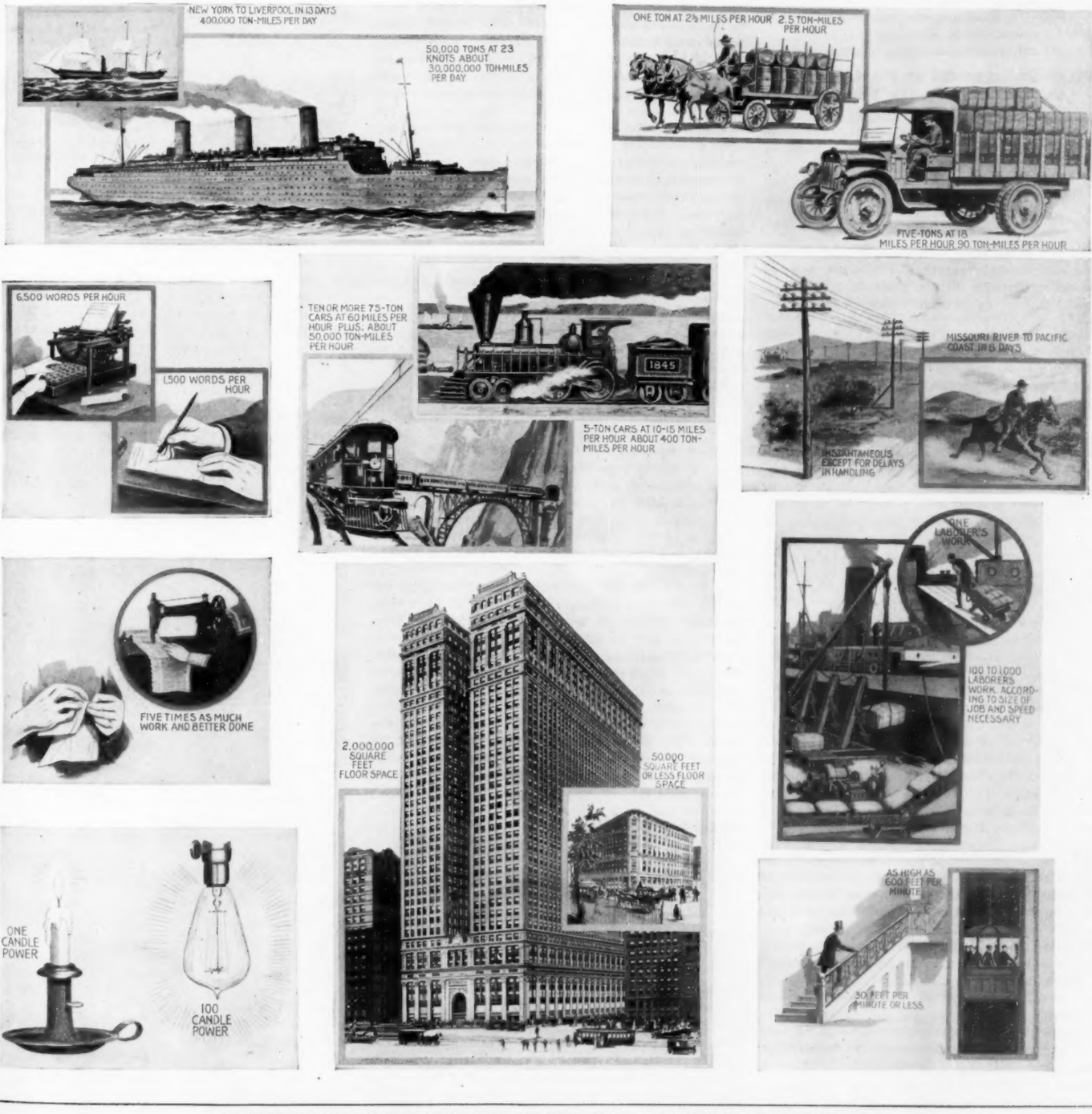
NEW YORK TO LIVERPOOL IN 13 DAYS
400,000 TON-MILES PER DAY
50,000 TONS AT 23 KNOTS ABOUT 30,000,000 TON-MILES PER DAY
ONE TON AT 2½ MILES PER HOUR 2.5 TON-MILES PER HOUR
FIVE TONS AT 18 MILES PER HOUR 90 TON-MILES PER HOUR
6,500 WORDS PER HOUR
1,500 WORDS PER HOUR
TEN OR MORE 75-TON CARS AT 60 MILES PER HOUR PLUS ABOUT 50,000 TON-MILES PER HOUR
1845
5-TON CARS AT 10-15 MILES PER HOUR ABOUT 400 TON-MILES PER HOUR
MISSOURI RIVER TO PACIFIC COAST 1918 6 DAYS
INSTANTANEOUS EXCEPT FOR DELAYS IN HANDLING
FIVE TIMES AS MUCH WORK AND BETTER DONE
2,000,000 SQUARE FEET FLOOR SPACE
50,000 SQUARE FEET OR LESS FLOOR SPACE
ONE LABORER'S WORK
100 TO 1,000 LABORERS WORK, ACCORDING TO SIZE OF JOB AND SPEED NECESSARY
ONE CANDLE POWER
100 CANDLE POWER
AS HIGH AS 600 FEET PER MINUTE
30 FEET PER MINUTE OR LESS

REPRESENTATIVE PROGRESS OF THE PAST SEVENTY-FIVE YEARS

SCIENTIFIC AMERICAN

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The object of this journal is to record accurately and lucidly the latest scientific, mechanical and industrial news of the day. As a weekly journal, it is in a position to announce interesting developments before they are published elsewhere.

The Editor is glad to have submitted to him timely articles suitable for these columns, especially when such articles are accompanied by photographs.

The Future as Suggested by Developments of the Past Seventy-five Years

INEVITABLY, after such an extensive retrospect of the fields of practical science as we have made in this commemoration of the 75th anniversary of the founding of the SCIENTIFIC AMERICAN, the thoughts of many of us will turn to the future. An outstanding impression left by a perusal of the early volumes of the SCIENTIFIC AMERICAN is the surprisingly large number of forecasts which the passage of the years has shown to be well founded, and we may find some not altogether unprofitable diversion in using the present opportunity to turn from the accomplishments of the past to possible developments of the future.

Civil Engineering

The profession of civil engineering has been so long established and has proceeded along such definite lines, that the future will probably witness no radical changes either in its principles or practice. The outstanding feature will be the scale on which the civil engineer, thanks to improvements in machinery and general appliances, will attack and put through works of unprecedented magnitude. The construction of the North River Bridge, now assured, will be followed ultimately by the building of a few other long-span bridges of equal or greater magnitude, such, for instance as a 4,000-foot span across the waters of the Golden Gate at San Francisco, another great cantilever bridge connecting Oakland with that city, and the proposed bridge at Detroit across the Detroit River. Where bridging is impossible, resort will be had to tunnelling, and it is probable that the next decade will see the completion of the 21-mile Channel tunnel, to be followed by one between Scotland and Ireland; while he would be a bold prophet who denied the possibility of devising methods by which a subaqueous crossing of the Straits of Gibraltar will be worked out, in spite of the depth of water and the unfavorable condition of the underlying material. In this connection, it is safe to predict that the ugly, noisy and distracting elevated railways will be banished from our city streets and placed underground, and that the imminence of a deadlock in surface transportation will lead in congested centers, to the double-decking of streets, with the separation of light and heavy traffic.

The rate at which we are using up our supplies of raw materials, in the shape of iron ores for the production of a sufficiency of steel, will become, if it has not already become, a serious problem. We may have to turn to other materials, and it is possible that a workable substitute, for certain kinds of structural work, will be found in the direction of improved aluminum alloys, with a lower ratio of bulk to strength and of lower cost.

The future will see a great development of both barge and ship canals—barge canals for the carriage of commodities in bulk which require no great haste in transit, and ship canals to shorten sea travel, or, as in the case of the proposed ship canal from the Lakes to the Atlantic, to enable freight to be carried from interior points to foreign ports without breaking bulk.

Transportation by Land

As regards transportation the question arises: Will the steam railroad continue to hold the primary position in the transport of passengers and freight? So far as speed and carrying capacity are concerned, they seem to have about reached the limit. The outside dimensions of mammoth locomotives, as represented by the "Virginian," are limited by the height and width of permanent structures. The steel Pullman weighing from seventy-five to eighty tons, and the latest steel coal cars of seventy-five tons' capacity, are subject to the same limitations. If rolling stock continues to increase in weight it will be necessary to revise our methods of track construction, and on the trunk lines of the future we may look to see roadbeds with a concrete foundation covered with broken-stone ballast, and laid with rails of from 150 to 200 pounds to the yard. Experience with the 125-pound steel rail now under test by the Pennsylvania Railroad, has shown that the life, both of track and rolling stock, is prolonged by using very heavy rails, of deep section, rolled from a harder steel.

If the railroad is to hold its own with the automobile, the airplane and the dirigible, the steam locomotive must gradually give way to the electric motor. Gradually, and with increasing efficiency, electric traction will be extended in its application, until the time arrives when our whole railroad system will be run from great central and inter-connected power plants, located at the sources of water power and at the mines. A careful estimate of the resulting economies were our whole railroad system electrified, reveals the astonishing fact that 122,500,000 tons of coal would be saved in every twelve months of operation. With the introduction of electric traction and improved track, we may look for an increase in train speed, and concurrently with this there will be an extensive application of the automatic stop. If it be not introduced voluntarily by the railroad companies, legislation, as in the case of the automatic coupler and the airbrake, will render it everywhere obligatory.

The immediate future will witness a keen competition between the automobile and the railroad; but this will ultimately give way to a well adjusted coöperation, as it comes to be realized that the one is the complement of the other. The main highways of the future will be of concrete construction. There will be a great increase in motor bus travel, and the bus will be developed until the passenger may make his journey over the highways with as much comfort and convenience as he now enjoys on the steam railroad. Ultimately, the "trunk" highways, if we may borrow a railroad term, will be widened out to accommodate four vehicles abreast, motor-truck traffic occupying the center, and fast passenger traffic the outside of the roadbed. It will not be many years before the pneumatic tire will be in universal use for motor-truck service. The motor of the future will be multi-cylindered, sixes and eights predominating; engine weights will be reduced; and power will be sought in high speed of revolution.

Apparently the only limit to the growth of the automobile will be the question of fuel supply. At the present rate of consumption, it is certain that before another seventy-five years have passed, some moderate-priced substitute for gasoline must be found. Otherwise the use of the automobile will have to be greatly curtailed.

Transportation by Sea

When we come to the question of travel by sea, we can speak with more certainty of the developments of the future. It is probable that in such ships as the "Leviathan" and the "Aquitania," we have reached the limit of size and luxuriance. For many years the steamship companies have claimed that these ships are profitable only as advertisements, and it is well understood that the best revenue earners and, in some respects, the most comfortable ships are vessels of the so-called intermediate type, which can carry a large passenger list and a big load of freight and maintain a speed of sixteen to eighteen knots. Not for many decades to come, if ever, will the Atlantic see a repetition of the speed contest for the famous "Blue Ribbon of the Atlantic." If such competition should occur again, it will be between boats of a special type, of moderate size, carrying no freight and only first-class passengers, and charging sufficiently high rates to cover the great cost of operation. If any firm wished to do so, it would be perfectly possible to build a turbine-driven, 35-knot transatlantic liner provided with limited and extremely high-priced accommodations. In the immediate future there will be an increasing use of both the electric and the geared drive, and if the economies claimed for the electric drive on our warships can be realized in the merchant service, the electric drive must ultimately become the universal type. Meanwhile, as the problems of the oil engine are mastered and the size of the individual cylinder increases, there will be a corresponding increase in the number of oil-driven ships. There is everything to be said in favor of the marine oil engine, and practically nothing against it. The oil engine, because of its many economies will ultimately drive out the marine steam engine, and nothing short of the giving out of the oil supply can stop its progress. When the oil wells of the world run dry, the motor-driven ship will have to give place to the steamship with its coal-fired boiler.

Aviation

IT is quite possible that the future historian will set down the present year as marking a new era in the history of aviation—the era of metal construction. As an advocate from the very first of the monoplane as against the multi-winged type, we are gratified to note that, so far as America is concerned, two of her entries for the approaching international cup contest are of the monoplane type, and that the most important of the new airplane postal routes, that from New York to San Francisco, is being operated by all-metal monoplanes. The monoplane is ideal for high speed, and because of its lower head resistance, or drift, it is the most economical type at any speed. It has been built in fairly large sizes, although, for the present, it seems likely that in the largest airplanes, recourse will be had to the biplane type. Excellent progress is being made in the development of a more effective form of wing, and unquestionably the airplane of the future will be capable of changing the angle of incidence during flight. When this has been done, the difficulties and dangers of taking off and landing will be reduced to a minimum, and the pilot will have a wider range of choice for a landing place in cases of forced descent. Similarly, in the near future we look to see a thoroughly reliable variable pitch propeller put upon the market. Results obtained with this device at the Army Flying Grounds at McCook Field are very encouraging; for it has been found practicable to change the pitch of the propeller to suit the altitude, and also to reverse it entirely at the moment of landing, thereby securing a braking effect, so powerful as to bring the machine very quickly to rest after it has reached the ground.

There will be a steady increase in the size both of airplanes and dirigibles. It is now realized that there is no inherent disadvantage, as was at first supposed, resulting from increase of size in the airplane. At the present time a seaplane is under construction which has a wing spread of nearly 250 feet; whose weight is over 50 tons, and whose radius is over 4,000 miles on one filling of the fuel tanks. The boat is of such size that full stateroom accommodation is provided for a considerable complement of passengers and crew. This is an enormous advance at one stride, and suggests that future airplanes and seaplanes may ultimately rival the smaller ocean-going steamships in dimensions. Reliability will be assured by a multiplicity of engines, the flying boat above mentioned having no less than eight, with a total capacity of nearly 5,000 horse-power As far as the dirigible is concerned, any increase in dimensions brings with it a greater relative increase in carrying power and all-around efficiency. Now that the question of landing has been solved by the provision of mooring towers, the risk of landing, even in heavy weather, has been eliminated. The flight of R-34 last summer from England to America and back has established the feasibility of trans-oceanic travel, and the last machine to be completed, R-80, in its recent trial trips has shown great improvement in control and maneuverability over R-34. This latest of the dirigibles has a cruising radius of 6,400 miles and a maximum speed of 65 miles per hour. Aerial travel will be

divided between the two types, the dirigible being used for long distance and trans-oceanic travel, while the airplane will be the standard machine on overland routes, where the distances between stops are shorter. Experimental work which is being carried on in this country in producing a steam drive for airplane service has given such promising results, that it is quite possible a combined steam boiler and steam turbine, admirably adapted for the larger machines, will be in extensive use within the next few years. One of the great advantages possessed by steam-driven airplanes would be the absence of the loud exhaust, an improvement which will be especially appreciated by the airplane passenger, and will prove to be of great tactical advantage in naval and military airplane service.

Pure Science

When the investigator in the field of pure science has unearthed new facts and new principles, it is often possible to predict with some accuracy just what use the inventor will make of these. But prediction in the field of pure science is another matter. The scientist sets forth over an uncharted sea, and the scribe, left behind on the dock, is asked what he may find at the other side of the waters. If the scribe knew, the scientist would not have to make his voyage.

Nevertheless, sometimes the scribe knows something about the ship in which the scientist is sailing, and enough about the waters over which he is to pass to hazard a guess as to his direction. And if one thing seems clearer than anything else when we try to see in what direction the ship of science is heading, it is that the process of generalization, shown on another page to have been the dominant note in scientific progress for the past three-quarters of a century, has by no means reached its culmination. We have but scratched the surface of the discoveries that wait to be made regarding the essential unity of matter and energy, and the direction of major achievement in the science of the next seventy-five years is here clearly outlined. If we are ever to find the way to utilize for our own purposes the vast store of energy locked up in matter, the way will lie through a better understanding of just what the correspondence is between these two entities. More specific than this we cannot be, or we should be steering the ship instead of watching from the shores for its return.

In the field of biology prediction can be more specific. We shall continue to pick up information as to how heredity works, until we shall be pretty well able to determine in advance physical and mental characteristics of animals a long way up the scale from the sand flies to which experiment is so far confined. Doubtless the goal here is the human animal; whether that goal will be attained is a matter of guesswork. If balked in the direct attack, we may at least hope to prevent the production of types running too strongly in the wrong directions physically and mentally.

Every age sees a new science—a whole body of phenomena and of the principles that govern them—developed where previously we had not even been conscious that there was a void in our knowledge. In the eighteenth century it was electricity; in the nineteenth, psychology. In the twentieth, it is the conviction of the SCIENTIFIC AMERICAN that it will be the field to which the rather unsatisfactory name of psychic has been attached.

We make this statement without any reference to the question of personal survival or that of communication with those alleged so to have survived. But the fact can hardly be escaped that there is a growing fund of well authenticated phenomena which are explained by no natural law yet formulated, and which seem to require that we postulate the existence of some force operated, consciously or unconsciously, by the human brain. Nobody, for instance, can deny the phenomenon of hypnosis. No careful person is going to deny categorically the accumulating evidence that there really is some sort of communication between individuals widely separated in space, to which the general name of mind-reading or thought-transferance or telepathy has been provisionally applied. We think we may, without being accused of having fallen victim to the post-war hysteria, suggest that when all cases of fraud and hypnosis have been ruled out, there is a residuum of material demonstrations of an as yet intangible force—things to which the hateful names of spirit-rapping, table-tipping, levitation, etc., must be applied until we get a more respectable term to take their collective place.

On all these grounds we are inclined to predict that there exists a force, operated through action of the human brain, that is capable of producing sensible effects and effects upon another brain. The science of tomorrow will tell us what this force is and will give us a control over it which may turn out to be as complete as our control over the electric impulses which today we shoot through the ether in utter defiance of all the experiment and all the knowledge and all the common sense of a generation ago.

Applied Electricity

Electricity in the rôle of man's faithful slave is so relatively young that one hesitates to say much regarding its future. Only yesterday Edison was trying all kinds of materials in order to obtain a suitable incandescent lamp filament; Bell was struggling with a toy called the telephone; and several experimenters were entertaining their friends by transporting them about on crude electric cars. And if such remarkable progress has been made in but a few past decades, there is a wonderful future surely for this new art.

In the generation of electricity there will doubtless be progress, but it seems certain that such progress will not be spectacular. The generators of today have attained very high efficiency, and unless some new principle displaces the electro-magnetic type on which our present power plants are based, the generators of tomorrow will merely be larger and of far greater output. This great power will be transmitted thousands of miles, as compared with three or four hundred miles today. There is no doubt but that the problem of long-distance transmission will be solved, and the solution will be in the nature of better insulation and the consequent use of extreme potentials. Better transmission, in turn, will make it possible and feasible to harness the mountain streams that are far removed from civilization. It will also bring about the reduction of coal shipments; for why transport coal hundreds and thousands of miles when it can be burned at the mines to drive generators, and its power can be transmitted electrically to the distant consumer?

The electric furnace is in its infancy. It will reveal many new electro-chemical wonders when its possibilities are developed on a larger scale through the medium of cheaper current. Electric heating too is bound to be extended as current becomes cheaper through the harnessing of water power and the solving of long-distance transmission. Electric cooking on a vast scale only waits for a better rate per kilowatt hour.

In the field of communication we can look forward to great things. The introduction of the vacuum tube—that marvelous offspring of the incandescent lamp—seems to reveal no end of wonders. Engineers and experimenters are daily discovering new uses for the vacuum tube in telephony and radio work. We already have trans-continental telephony, and we may look forward to transatlantic telephony in the no distant future.

Radio communication is a newcomer in the field of applied electricity, yet it is a giant in point of development. True, this method of communication still leaves much to be desired, and it is the missing factors that must be supplied by future workers. Static—electric disturbances of the atmosphere—must soon be eliminated. Further introduction of faster automatic transmitters is certain, so that a tremendous volume of traffic will be handled by a given station, with subsequent reduction in toll rates.

In the field of illumination electricity has found a ready place. Nothing else can compete with it. And there seems no reason to doubt the ever-increasing use of electricity for illumination, especially when we are already facing serious shortage of heavy oils and other ingredients entering into the manufacture of illuminating gas. We have the one-half watt per candlepower lamp now; is it not safe to prophesy the one-tenth watt per candlepower lamp in the future?

The transmission of photographs over wires and by wireless; seeing the image of the person to whom you are speaking over the telephone; subscribing to concerts and motion pictures for the home, the service being distributed over the usual telephone lines by a central studio; frictionless electro-magnetic transportation systems that will attain hundreds of miles per hour; the transmission of electricity by wireless—all these things seem visionary today, but certainly no more so than our present attainments would have seemed to our forefathers of 1845.

Industrial Progress

Whatever may be the reason for the present shortage of labor, one thing seems certain, and that is the permancy of labor shortage or, to put it another way, the continuation of high labor costs. For it is not so much the number of unfortunates killed and maimed in the late war, nor again the need for replenishing the world's depleted stores that is responsible for the labor shortage, as it is the question of higher standards of living demanded by workingmen the world over.

So it has come about that workmen, who a few decades ago looked upon all machinery as evil competitors that were being introduced for the purpose of taking that much of their livelihood away from them, are now insisting on the use of machinery wherever possible. This spirit is on the increase. Laborers today resent doing work by hand that can be done by machinery to better advantage; for they realize that better and bigger production must mean an all-round rise in the standards of living.

The era of quantity production is already well under way, but more may be expected of it as the years go by. With labor co-operating in the development and introduction of such processes and machinery, we shall have more labor available for a variety of tasks which today must go unattended through lack of spare hands. Already we have attained high efficiency in many of our leading factories, where the men do not even have to move away from their bench in order to work on thousands of parts and assemblies which come and go from their hands in a steady stream. Automatic conveyors are going to play a tremendous rôle in future industry; we have only begun to make use of these remarkable labor savers. Automatic machinery is still in its infancy, despite our seemingly wonderful attainments. We are doing wonders in drop-forging, casting, and so on.

But where will these products be sold? Will the market not be saturated? Is there not a serious danger of over-production?

It must be remembered that our world—that is, the world with which we do business—is still small. The day is coming when we shall be called upon to provide the Africans and the Asiatics with all manner of useful things, and with the vast populations of those neglected continents as potential buyers of our products, we shall require far greater industries than we have today. Greater production will lead to increased commerce, and we shall have to conduct international trading on a vast scale in order to dispose of our machine-made products. In exchange we shall obtain natural products and other things which are still classed as luxuries because of the limited trade of today. All of which will go far to raise the standards of living throughout the world.

There is only one threat in the way of industrial progress, and that is fuel shortage. Coal is becoming less plentiful, as the decades go by. Oil is becoming scarcer. The future will have to call into play a number of substitutes for these staples of our present life. It may be that alcohol will prove the best fuel to carry on the world's business, for alcohol can be made from a variety of inexpensive ingredients by a simple process. It has been pointed out that an almost unlimited supply of alcohol is available in the tropical jungles, where the prolific vegetation can readily be treated if suitable alcohol-producing plants are conveniently installed. Then there are the water power resources to help out.

Industrial progress must continue, and its future is larger and better than the present. Our problems of today are but those of a transitory period, which, when gradually solved, must lead to better conditions for manufacturer, workingman, and consumer alike.

Seventy-Five Years of Invention

A Record of Progress, Decade by Decade

1845–1855

IN 1846 Richard Marsh Hoe made valuable contributions to printing machinery. He developed the type revolving press of the period in which a single form of type was carried beneath four, six, eight, or ten printing cylinders and used to print upon a sheet borne by each. Later Stephen Tucker converted this into the perfecting press (one that printed on both sides of the sheet). Eventually he adapted his machine to print upon a web or endless sheet of paper.

Of the improvements in civil engineering that deserve to be noted, it must be mentioned that in 1846 the French engineer Fauvelle invented the process of boring by forcing water under high pressure into a hollow boring tool. In 1852 Merriweather, a California miner, invented the hydraulic system of mining gold.

The modern bicycle seems to have had its origin in 1854. P. H. Fischer, a mechanic of Schweinfurt, Germany, added pedal cranks to the velocipede. Ernest Michaux hit upon the same idea in 1855.

In steam engineering the most notable achievement was undoubtedly George H. Corliss's invention, in 1848, of his famous valve gear, patented in 1849. The first steam boiler with horizontal iron tubes was constructed in 1855 by Julien Belleville. Wilcox built his first steam water-tube boiler with inclined water tubes in the same year. In the year 1840 Henry R. Worthington conceived the idea of applying steam to the propulsion of canal boats and in that connection invented the independent single direct-action boiler steam pump—beginning manufacture in 1845.

This decade marks the beginning of the high explosive industry; in 1845 Christian Friedrich Schoenbein discovered guncotton.

Industrially, by far the most important invention of the decade was the Bessemer process of making steel, *i. e.*, the direct conversion of molten cast iron into steel by blowing air into the molten mass. Henry Bessemer invented the process in 1855.

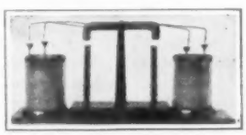
During this decade Stephen Fitch furnished a screw cutting lathe with a number of tools set in a holder which could be revolved to bring them successively to the work. This was the first turret lathe. In 1855 the Jones and Samson Machine Company produced a turret lathe in which the turret was turned automatically. The milling machine, originally invented by Eli Whitney, of cotton gin fame, in 1815, was further developed in 1853 by Frederick W. Howe, and this was followed in 1854 by what has since been known as the Lincoln miller, designed by F. A. Pratt of the Pratt & Whitney Company.

On September 10, 1846, Elias Howe received a patent for his epoch-making sewing machine. The features that made Howe's machine a success were a needle with the eye at the point, a shuttle operating beneath the cloth to form the lock stitch, and an automatic feed. To Allen B. Wilson we are indebted for the rotating hook and the four-motion feed. His first machine was built during the spring of 1849. In the same year he built a second and better machine which he brought to New York in order that he could exhibit it to the Editor of the SCIENTIFIC AMERICAN. In 1851 Wilson patented his famous rotating hook, which performs the functions of a shuttle by seizing the upper thread and throwing its loop over a circular bobbin containing the under thread. In 1859 Gibbs, a Virginia farmer, saw in the SCIENTIFIC AMERICAN a picture of a sewing machine. The working of the apparatus was very plain down to the moment when the needle perforates the cloth, and he fell into the habit of musing upon the course of events after the point of the needle was lost to view. The result of his cogitations, aided by infinite whittling, was the ingenious little revolving hook, which constitutes the peculiarity of the Willcox & Gibbs machine. In 1851 Isaac Merritt Singer brought into the business a new machine. The novelties consisted in the circular feed wheel below the cloth plate, which had a serrated periphery projecting slightly above the plate, and was fed by a rock shaft and pawl; a thread controller; and the use of gear wheels and shafting to transmit the power from the hand wheel to the two countershafts for working the vertical needle and the shuttle. Singer was also the first to introduce foot power in place of the hand-driven crank wheel. John Brooks Nichols, a Lynn shoemaker, about the year 1851 adapted the Howe sewing machine to sew the uppers of shoes.

Sewing machine patented by A. B. Wilson in 1850

The first power elevator was installed in 1852 by Elisha Graves Otis; and a few years later he exhibited at the Crystal Palace, in New York, the first elevator with a safety device to prevent the car from falling when the cable broke. The first exclusive passenger elevator operated by steam was installed in the Fifth Avenue Hotel in 1859 by Otis Tufts.

The efforts of inventors to produce a telegraphic printing machine gave impetus to the idea of a writing machine. In 1843, Charles Thurber of Worcester, Mass., patented a slow typewriter. The model was interesting as effecting the letter spacing by longitudinal motion of a platen—a principle which is a feature of all modern machines. In 1847 Dr. Francis patented a typewriter in which a motion similar to that of a piano hammer was employed to throw up the types, which were arranged in a circle, thus bringing them to a common center.



Reciprocating bar motor of Joseph Henry, patented in 1831

In 1831 Cyrus H. McCormick of Virginia built the first practical grain harvesting machine. But it was not until 1845, the year in which the SCIENTIFIC AMERICAN was established, that the reaper was really introduced. It contained the essential elements that have been found in every grain harvester that has proved a success from that day to this. The most important feature was the sickle consisting of a bar with projecting fingers through which a knife reciprocated. The grain, forced to the sickle by a reel, was cut and dropped upon a platform. A man, walking alongside the platform, removed the grain with a rake. The next improvement was the addition of a seat for the man who raked the grain. In 1849 Jacob J. and Henry F. Mann patented a machine having a series of endless bands for carrying the grain, after it had been cut and reeled upon these bands, to the side of the machine, where it accumulated in a receptacle until a sufficient amount had been gathered to form a bundle, when the operator dumped the receptacle, leaving the gavel upon the ground. In 1850 Homer Atkins invented a device for giving a reciprocating, intermittent motion to a rake, in order to deposit the grain upon the ground, after it had been cut and reeled upon the platform. In the summer of 1850 Augustus Adams and J. T. Gifford of Elgin, Ill., built probably the first hand binding harvesting machine.

1855–1865

The decade is notable for the important work done in laying the foundation of modern electrical engineering. The direct current motor, and the storage battery belong to this period.

The first modern coke oven of the by-product recovery type was built in 1856 by Carvès at Lebrun, Commentry. The principle of centrifugal casting in the production of iron and steel, although proposed as early as 1839, was practically carried out by Henry Bessemer in 1856.

The first modern hydraulic press was built in 1858 by Robinson and Gotham for iron works, but hydraulic press forging was substituted for the hammer in 1861 by John Haswell. Haswell's press was improved by Reiner Daelen in 1865 by applying steam pressure directly, thus dispensing with a pump and an accumulator.

Most important in its general industrial effect was the invention of the regenerative gas furnace by Friedrich and William Siemens in 1856.

On August 28th, 1859, G. L. Drake, while driving an artesian well struck oil. The first really successful pipe line was laid by Samuel Van Sycle in 1865 between Pithole and Miller's Farm.

The modern ammonia absorption ice machine was devised in 1860 by the French engineer, F. P. E. Carre. Improved by Reis (1870) and by Koch and Haberland (1871), this machine held its own until the compression apparatus was brought to a high state of efficiency. A closed cold-air or refrigerating machine was built in 1862 by A. C. Kirck.

Finding that his early pump lacked smoothness in operation, Worthington developed the duplex pump, which he patented in 1859. Another inventor who did much to improve the pump was George F. Blake. In 1862 he installed and operated his first single direct-action pump. In the same period belongs the development of the Knowles pump. In 1863 Holly constructed the first water-works plant in Lockport, N. Y., consisting of a rotary pump, turbine water wheel, about one mile of water main and twelve fire hydrants.

In steam engineering we must note that in 1858 John Elder combined the compound steam engine with the surface condenser, and thus devised a type of double-expansion compound engine, which has markedly influenced the development of marine engineering.

In 1860 Lenoir patented his historic gas engine, in which he actually used electrical ignition.

In 1861 Joseph R. Brown developed the universal milling machine. Cylindrical grinding began in this decade and in 1864 a grinding machine was put on the market by the Brown and Sharpe Company.

The decade brought forth the Solvay soda process, invented by the Belgian chemist and engineer, Ernest Solvay.

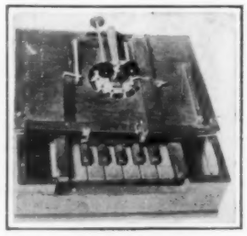
The type revolving printing press was in general use until Bullock introduced his stereotype perfecting press in this decade. This cut the sheets from a web before they went to the printing cylinders. Between 1862 and 1864 Andrew Campbell put out the first cheap cylinder press. Campbell then built his two-revolution printing machine (1865-1870), which has since become the standard press throughout the world.

In 1857 Snell and Bartlett patented their mechanical let-off for warps, an important improvement in textile machinery. The principle of this warp let-off was to actuate the large warp beam containing the warps at the rear of the loom by a ratchet and pawl connection with the oscillating lay, the movement of this ratchet and pawl-actuating mechanism being controlled by the tension of the warps.

It was in this decade that George Pullman introduced the Pullman car. In 1867 he devised the combined drawing-room car, which could be converted into a sleeper at night.

Bushnell in 1775 built the first practical submarine boat, and Fulton in 1801 employed the usual vertical rudder and a horizontal rudder. Although Bauer, a Bavarian, constructed a submarine vessel in 1850, no substantial advance was made until Bougeois and Brun completed "Le Plongeur" in 1864.

The year 1858 marks the beginning of the wonderful modern shoe machine industry, for then it was that Lyman R. Blake invented a machine which sewed the soles of shoes to the uppers. In 1862 Auguste Destouy invented a machine with a curved needle to sew turn shoes, which was improved by Daniel Mills in 1869. This machine was adapted by Charles Goodyear to the sewing of welts. Goodyear patented his machine in 1871 and 1875.



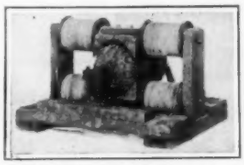
One of the pioneer typewriters, patented in 1868

A marked advance in typewriting machines was made in 1856 by Mr. Alfred Ely Beach, Editor of the SCIENTIFIC AMERICAN and one of the founders of Munn & Co. This machine was primarily intended for the printing of embossed letters for the blind, but could also be adapted to the general uses of the typewriter. During the winter of 1866-1867 C. Latham Sholes, a printer and editor by trade, and Samuel W. Soulé, also a printer, inventor and farmer, were engaged together in developing a machine for serially numbering the pages of blankbooks. Carlos Glidden became interested in Soulé's machine and suggested the idea of devising a mechanism which would write letters and words. In the following year a copy of the SCIENTIFIC AMERICAN fell into the hands of Glidden. It described a machine called the pterotype (winged type), invented by John Pratt, which was designed to do just what Glidden had suggested. This article was brought to the attention of Sholes. Glidden, Soulé, and Sholes eventually formed a combination to

develop a practical machine. By September of that year the first machine had been made. James Densmore of Meadville, Pa., was attracted to the new enterprise and purchased an interest in it. He urged further improvements, pointing out many defects. Soulé and Glidden dropped out of the enterprise and left it entirely to Sholes and Densmore. By 1873 the machine had been developed so far that it was felt it could be manufactured, and with that end in view Densmore came, in 1873, to the gun factory of E. Remington & Sons of Ilion, N. Y. At the factory of the Remingtons the machine was further developed and was finally placed upon the market about the middle of 1874.

1865–1875

Modern electrical engineering is placed on a sure footing in this decade; for we find not only the dynamo and the motor vastly improved, but new applications of the electrical current made on every side.



Early type of dynamo for supply current to arc lamps

Sylvanus D. Locke, in 1873, after associating himself with Walter A. Wood, built and sold probably the first automatic self-binding harvester that was ever put upon the market. The use of wire as a binding material met with opposition, and the inventors turned their attention to perfecting an attachment that would bind with cord; and to Marquis L. Gorham of Rockford, Ill., who built a successful cord binder and had it at work in the harvest field in 1874, must be given the credit of producing the first successful automatic self-sizing binder.

Jacob Reese, an American inventor, in 1875, built a machine for cutting iron and steel with rapidly rotating disks of soft iron. In 1872 A. Brandon developed a file-making machine, which, in imitation of hand labor, applied chisel and hammer separately. However, it could be used only for making flat files. It was improved by Maurice Mondon of London, in 1874, so that convex filing surfaces could be made. The modern machine, however, was invented by Disston of Philadelphia. The idea of rolling instead of forging files was carried out in 1864 by B. H. Dodge, who constructed a machine for that purpose. In 1866 William Sellers and Company developed an automatic machine for cutting gears which operated on the formed tool system. The first commercial automatic machine, however, was produced by Brown and Sharpe in 1877.

George Bedson of Manchester in 1867 invented a continuous wire rolling mill. He was the first to roll out metal bars weighing one hundred pounds into wire at the rate of eleven tons a day.

Railroading received a great impetus by George Westinghouse's invention of the air brake.

An invention which attracted but little attention at the time, but which was the beginning of the reinforced concrete industry appeared in 1867. Then it was that Jose Monier patented a method of making flower pots out of cement with a reinforcement of iron netting.

Benjamin C. Tilghman invented the sand blast in 1871 for producing mat glass. His invention was afterward introduced into the iron and stone industries. Tilghman is also to be credited with the invention of chemical wood pulp. After he had pointed the way, George Fry and his collaborator, Ekman, developed at Bergvick, Sweden, the process of separating the cellulose of wood by boiling it under pressure in an aqueous solution of sulfur dioxide in which magnesium sulfite was dissolved.

In 1862 Joseph Moore of San Francisco brought out the California stamp mill, which became of great importance in mining. The dry concentrator in which air is employed for the separation of minerals was introduced in 1868 by Stephen R. Krom. Another improvement was Dingey's mineral mill (1872) consisting of a slowly revolving horizontal slotted plate over which four notched disks rotated in the opposite direction.

A rotary knitting machine was built by Lamb of Valparaiso, Indiana, in 1866. This machine was afterward improved by Dubied and Watteville. It made a stocking without any seam whatever.

The first great modern vacuum ice machine was exhibited by Edward Carré at the Paris Exposition of 1867. In this machine water was used as the vaporizing fluid and concentrated sulfuric acid as the absorbing fluid.

In 1873 Lowe and White invented the modern water gas process. Another improvement in the art of illumination was that of C. Tessié du Motay, who invented the zircon light in 1867, in which a pencil of zircon was heated to incandescence in a gas blowpipe. Clammond, in 1872, hit upon the idea of bringing magnesia to incandescence in a blowpipe. In a sense he was the forerunner of Welsbach.

J. S. Hyatt discovered in 1869 that camphor is a solvent for various kinds of nitrocellulose and thus established the great modern celluloid industry.

Dynamite was invented in 1867 by Alfred Nobel. He discovered the extraordinary absorptive powers of the infusorial earths for nitroglycerine.

Madison improved the bicycle in 1867 by providing it with radial wire spokes.

On September 5th, 1865, Alfred Ely Beach, Editor of the SCIENTIFIC AMERICAN, patented a plan for conveying letters and parcels by mechanical means directly to a central post office from a lamp-post letter-box. In the following year he learned of the success of experimental pneumatic tubes in Great Britain, through which small cars carrying merchandise and persons in a sitting position were successfully operated. Thereupon he invented a plan of dispatching letters pneumatically. X-shaped revolvable valves in lamp-posts were intended to catch the letters as they were dropped from above, and to hold them until the pneumatic car came along, into which they were emptied automatically. A pneumatic subway under Broadway was the next development, the modern tunneling shield, suggested as early as 1824 by Brunel, being practically applied. The shield was pushed forward in a modern way by a series of hydraulic rams, which system Mr. Beach patented June 8th, 1869. With this shield a tunnel was driven under Broadway from Warren Street to Murray Street. A car was propelled through this tunnel by means of a blower, the blower being reversed so as to suck the car back when it had reached the end of its travel.

Pioneer gear-cutting machine of Joseph R. Brown, 1885

Almost simultaneously with the steam elevator appeared the hydraulic elevator, which in its simplest form was a ram located under the carrying platform, which was moved up and down by water under pressure, working in a closed cylinder. This system of operation was first put into practical use in 1872. Following this type came the geared hydraulic, in which the ram became a piston, which was attached to the moving element of a system of multiplying sheaves, over which the elevator cables were passed, thus enabling a short cylinder to effect a high lift.

1875–1885

This was primarily a decade of electrical invention. Edison's incandescent lamp and Bell's telephone were the outstanding inventions of the period.

In 1877 the phonograph appeared, one of Edison's most original and brilliant inventions. Its first public demonstration was in the office of the SCIENTIFIC AMERICAN toward the end of the same year.

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Recording the voice of the American Indian for posterity

In 1883 Sir Hiram Maxim invented his automatic (self-loading) machine gun, in which he utilized the force of the recoil to reload the weapon as well as to fire it automatically. Most modern machine guns have been based upon this early weapon of Maxim's.

Andrew Campbell in 1875 developed a press which used curved stereotype plates and printed on both sides of the web itself. Later Campbell added a folding machine. Next he built a double printing machine, each half of which contributed a perfected web to a folding machine common to both, whereby he was able to turn out an eight-page paper. Stephen D. Tucker, an inventor in the employe of Hoe, also invented a folder. He applied for a patent (1875); Campbell did not. Hence, one of the most valuable improvements in printing presses fell to the Hoes. At about the same time Tucker invented the collecting cylinder, by means of which the product of one circumferential half of a printing cylinder may be transposed upon the product of the following half, and thus the two brought together as a single product. Two Englishmen, Anthony and Rose, conceived the idea of splitting a web of paper into two longitudinal halves and transferring one-half over and upon the other by means of deflecting bars, so that the right-hand product of a printing cylinder could be superposed upon its left-hand product and the two made up into one. This invention is now included in all double-width newspaper printing presses. Another improvement came when Ford patented a means for running the product of two printing machines into one folding machine. Crowell, an ingenious Yankee skipper, invented the longitudinal folder, by which a web may be folded longitudinally while on the run and still in web form. About the same time (1879-1889) he conceived the idea of the rotary fly. This was the last device necessary to the creation of a 24,000-copies-an-hour printing press, and when it was introduced (in the early eighties) the rotary newspaper printing press in all its elements became the machine it is today.

The universal grinder which has been in process of development for a number of years at the hands of Joseph R. Brown was exhibited at the Centennial Exposition. The generating system of gear cutting was invented by Hugo Bilgram in 1881.

Important progress in metallurgy was made. After M. J. Holway had made experiments in bessemerizing copper (1877-1878), following the experiments of Semennikow, M. J. Brown of Sheffield succeeded in blowing Rio Tinto ores in Bessemer converters. The modern Otto by-product coke oven, an improvement on that of Bauer and Hoffmann, was introduced in 1880. Alexander and MacGosh invented the so-called Gartsherrie process for obtaining ammonia and tar from blast furnace gases.

The first two-cycle gas engine appeared in 1879. It was the invention of Clerk and was distinguished by its separate compression pump, which charged the working chamber and also acted as a scavenger. The first gas engine for locomotives was built in the same year by Marcel Deprez. The gas was compressed in a suitable container, and after having been allowed to work expansively like steam, was mixed with air, exploded, and thus made to do work again. In 1880 the French engineer, Serpollet, constructed a steam engine for tram cars employing a flash boiler. But the crowning invention in engines was the steam turbine. In 1884 Charles Algernon Parsons of Newcastle-on-the-Tyne invented his multi-cellular turbine, which utilizes steam first on the action and then on the reaction principle.

In the same year Pelton, an American, invented the Pelton wheel, in which cups are used instead of blades, the cups being so designed that they utilize the force of the impinging water to the utmost limit of possibility.

For many decades inventors had endeavored to supply a satisfactory machine for setting type. It was not until 1888 that such a machine was invented. It was the invention of Ottmar Mergenthaler, and it worked on an entirely new principle. Instead of setting the types and after their use distributing them among their respective receptacles, Mergenthaler employed the type-matrices, and from these cast, as a single piece, a line of characters. Hence, his machine was called a "linotype." On the heels of the linotype came another device—the "monotype," invented by Lanston. This monotype consisted of two independent mechanisms, the one a keyboard by means of which the operator was enabled rapidly to perforate a paper ribbon with holes which represent characters, and the other a type-casting mechanism controlled by the perforated ribbon.

The first really successful modern volatile hydrocarbon automobile had its origin in this decade, as described elsewhere in this issue.

In 1876 J. P. Holland built a submarine vessel (the "Fenian Ram"), following the Fulton system of control by vertical and horizontal rudders. She was fitted with an air gun which could be discharged under water, and was probably the first submarine torpedo boat, if we give the word torpedo its largest significance.

In 1880 Alexander E. Brown installed the first mechanical ore unloader to take ore from the hold of a boat and deliver it either to cars or to stock piles without rehandling.

During this period the Ekman paper-pulp process was markedly developed. Mechanical difficulties surrounded the operation from the start, though the quality of pulp produced was excellent. The digesters in which the wood was cooked were lined with lead and the heat developed in the acid liquor proved to be exceedingly disturbing, as while the lead expanded during the application of heat, it did not contract again

when cold. The difficulty was overcome by the invention of a digester lining composed of heavy cement backing, faced with brick, the latter being pointed with litharge and glycerin.

Perhaps the most important invention in pulp-making processes, especially in view of recent work in the utilization of waste wood, dates from 1883, when Dahl introduced the sulfate process for the treatment of straw, a modification of which is now applied to the production of pulp from coniferous woods that are not amenable to other treatment.

1885–1895

The turret lathe with flat style of turret was invented by James Hartness in 1889 and was further improved in 1891. In 1894 Conrad M. Conradson invented a lathe with hollow spindle through which the work could be fed to the machine.

Blanchard duplicating lathe built in 1843

The year 1893 marks the publication of Rudolf Diesel's "Theory and Construction of a Rational Heat Motor," in which he set forth the principles of the well-known Diesel engine. In 1887 Gustaf de Laval invented his high-speed steam turbine, in which the potential energy of the high-pressure steam is transformed into kinetic energy in a single stage and imparted to the shaft. In the same year he designed his centrifugal cream separator, which ever since has been widely used throughout the dairy industry.

In 1894 Bénier patented the suction producer-gas plant in which the motor is made to draw its gas from the generator, thus producing a depression in the generator which is filled by air below atmospheric pressure. This air is mixed with steam and forms new gas in passing over the layer of glowing fuel.

The first attempt to use compressed illuminating gas was made by Julius Pintsch in 1891. His system, properly developed, made it possible to illuminate railway trains with gas.

The famous McArthur-Forrest cyanide process, which has been of immense importance in gold mining, was brought out in 1887 by Robert William Forrest, William Forrest, and John McArthur. These investigators found that the effect of potassium cyanide depends upon the weakness of the solution. The gold mines of the Transvaal took up the process almost as soon as it was introduced.

The possibilities of the electrical furnace were never before so brilliantly revealed as in this decade. In 1862 Woehler discovered that water acting on calcium carbide would produce acetylene. The next step was to make calcium carbide cheaply. An early attempt with the electric furnace was that of Henri Moissan (1892), who succeeded in making calcium carbide out of marble and sugar carbon. Then came Thomas L. Willson, to whom the credit is really due of placing the manufacture of calcium carbide upon an industrial basis, which he achieved in 1892 in coöperation with Dickerson. Paul Héroult constructed the cathode furnace (1887) for uninterrupted operation and thus becomes the founder of the electrometallurgy of aluminum according to the smelting method. Edward G. Acheson succeeded in 1892 in making silicon carbide in the electric furnace—an abrasive which has been known to the trade as carborundum. He also obtained artificial graphite in the electric furnace for the first time.

The first commercially successful process for making artificial silk was that brought out in 1885 by Chardonnet, who squirted nitro-cellulose under pressure through small holes in water, alcohol, chloroform or the like, the threads congealing at once.

John B. Dunlop, a dentist of Dublin, Ireland, invented the pneumatic tire in 1890, as we know it today. He seems to have been quite unaware of Thomson's pioneer work in the same line (1846).

Edison's experimental success with his tinfoil phonograph in 1877 proved the starting point of much valuable investigation in sound production by himself and others. In 1886 Dr. Chichester Bell and Charles Sumner Tainter patented their method of recording and reproducing sounds by engraving a wax or wax-like substance, thus producing records that could be removed from the machine, handled and transported. In 1887, Emile Berliner invented the gramophone or disk graphophone and worked out for practical use the system of duplicating disk records, which has been in use ever since.

Goubet of France built several submarine torpedo boats between 1885 and 1890. The novel feature was his propeller, which worked on a universal joint so that it could be changed as to the direction of thrust. It took the place of vertical and horizontal rudders. Prof. Josiah Tuck carried on experiments with his submarine ("Peacemaker") in the Hudson River in 1885, using caustic soda to generate steam. His boat had a water lock through which a man, clad in a diving suit, could pass. Several other submarines were built in Europe during this period. The most successful of these was perhaps the "Gymnote" built in France after the designs of Dupuy de Lome and Gustave Zédé.

In 1893 the United States Navy advertised for bids for the construction of a submarine. J. P. Holland, George C. Baker, and Simon Lake handed in plans. Baker's design was based on the performance of a vessel he had experimented with in 1892. Holland submitted plans for a steam vessel of the diving type with horizontal rudders at the stern for changing the inclination of the vessel, as first used by Fulton. Lake submitted a design for a vessel with an inner and outer hull, the inner space to be utilized for water ballast. This vessel was designed to be operated submerged on a level keel by the use of hydroplanes; bottom wheels were provided to enable the vessel to be navigated on the water bed itself; air locks were called for to enable the crew to escape in case of danger. Holland secured the Government award because of his previous experience. His vessel, the "Plunger," was not a success, due to her enormous steam installation, which made the interior of the boat unbearably hot, and to her lack of stability. Lake's idea of running along the bottom on wheels—an entirely new conception in the art—received its first demonstration in 1894. This craft was the germ from which later emerged his "Argonaut" (1896-1897), the first submarine to be fitted with an internal combustion engine.

1895–1905

This is the decade of the airplane and the airship and of wireless telegraphy, all of which are described elsewhere in this issue.

A vertical turret lathe appeared in 1901. This was the invention of E. P. Bullard. The Bilgram gear-cutting machine was improved in 1898 by J. E. Gleason. The most important development in the field of machine tools was the invention of high-speed steels by Frederick W. Taylor and his associates which made possible heavier cuts and higher cutting speeds.

In 1897 Hans Goldschmidt of Essen invented the well-known thermit process. Thermit, however, was not introduced commercially until 1899. The modern process of autogenous welding was introduced in 1905 by Fouché, oxygen and acetylene being used in a specially constructed blowpipe.

An attempt to reduce nitrogen from the air electrically was made in Niagara Falls by Bradley and Lovejoy in 1900. This experiment, while not commercially successful, at least served to inspire later work. Thus Christian A. Birkeland and Samuel Eyde built their Norwegian plant in 1903, using electric arcs spread out by magnets so as to obtain a great heating surface.

The steam turbine was markedly developed during this period. C. G. Curtis invented in 1896 his multi-stage pressure turbine. A. Rateau in 1898 constructed his multi-stage pressure turbine. Zoelly in 1902 constructed a multi-stage pressure turbine which is essentially similar in principle to that of Rateau. A. Rateau invented the first turbo-compressor in 1900 and a turbo-pump in 1902.

The principle of utilizing internal work in liquefying air as well as the counter-current principle of refrigeration was discovered in 1898 by Karl P. G. Linde. The outgoing air was used to cool off the air still contained within the apparatus so as to produce a cumulative refrigerative effect. He built a refrigerating machine on this principle with which very low temperatures were reached.

In 1898 Ochelhäuser of Dessau installed an engine in the Hörde Iron Works for the utilization of blast furnace gases; the engine itself was patented in 1896, and was a two-cycle double piston engine. The Körting blast furnace gas engine was brought out in 1898. Cockerill of Seraing, Belgium, introduced a four-cycle blast furnace gas engine in 1899. From this the two-cylinder blast furnace gas engine of the Nürnberger Maschinenbau Aktiengesellschaft was shortly evolved.

In 1904 James A. Gailey brought out his dry blast process for the production of iron and steel. He solved the problem of drying the air by freezing out the water.

The American iron industry suffered a great change in this decade. The Mesaba ores were being introduced. Since the blast furnaces were far removed from the Lake Superior beds cheap handling was an essential, a consideration met by Brown's bridge cranes, cableways, and trolleys. A radical departure was made in ore handling when G. H. Hulett in 1898 invented the automatic ore unloader bearing his name.

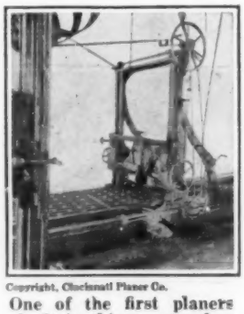
In 1897 Karl Engler made exhaustive researches on the decomposition of hydrocarbons when subjected to heat and pressure. Thanks to him much light was shed upon chemical reactions, which take place when oil is cracked. Most cracking processes are based upon the methods disclosed in patents taken out in 1890 by Dewar and Redwood. The Dewar and Redwood process is in turn an outgrowth of the Krey high-pressure distillation process of 1887.

The method of hydrogenating soft fats and oils, whereby it is possible to convert vegetable oils into substitutes of lard and some fats into hard fats of greater commercial value was discovered in 1902 by P. Sabatier and J. B. Senderens.

The separation of ores by oils was introduced in 1902 by W. Elmore. The ground ore mixed with the residue of petroleum distillation was placed in rotating cylinders so that oil and pyrites are intimately mixed. The oil was then centrifugally separated.

In 1899 William Draper constructed a loom with automatic shuttle-changing mechanism, the first practical success of its type, and the result of ten years' experimenting. The present type of automatic bobbin-changing loom was the outgrowth of an invention made by James H. Northrop, who conceived the idea of changing the bobbin in the shuttle automatically while the loom was in motion. On June 23rd, 1891, Rhoades received a patent for shuttle-changing mechanism, which applied the principle of the weft fork for detection of the absence or the failure of filling and of an ejector to the changing of a shuttle in which the filling was exhausted. An early patent for automatic weft-replenishing looms, especially adapted for multi-colored weaving, was granted to Wyman and Crompton in 1898.

After Campbell, Tucker and Crowell, had brought the newspaper printing press to a point where 24,000 to 29,000 copies could be printed an hour, no marked improvement was made until Henry Wise Wood introduced radically new ideas. Instead of drawing the paper through the press—a proceeding which subjected it to strain and reduced the speed of printing for fear of breakage, Wood carried it along bodily without strain to the printing types. The machine adjusts itself automatically to the peculiarities of the various paper rolls, so that breakages are avoided and the amount of attention required by the press is reduced to a minimum. The paper is handled in streams and assembled in a single stream made up of as many thicknesses as the newspaper to be printed has leaves. This combined stream is then folded, cut and delivered at the rate of 60,000 an hour (eighteen to thirty-two pages).



Copyright, Cincinnati Planer Co.

One of the first planers built in this country by Ira and Ziba Gay

1905–1915

In 1900 stereotyping was revolutionized by the introduction of Henry Wise Wood's "Autoplate" machine. This consists of a casting mechanism and a series of finishing mechanisms which automatically coöperate in one machine to make casts and finish them. When used to make plates of the conventional half-inch thickness its speed is four finished plates a minute; but when the thickness is but one quarter of an inch eight plates a minute are easily obtained.

In the field of machine tools the decade is marked by important improvements in gear cutting machines of the generating type. J. E. Gleason obtained patents in 1907 and 1910 and E. R. Fellows in 1907, 1908, 1911 and 1912.

One of the notable developments of the decade was the use of the gyroscope in a great many widely different applications. Mr. Louis Brennan, inventor of the Brennan torpedo, devised a gyroscopic monorail. This renewed interest in the previous invention of Schlick, who used a gyroscope to keep a ship from rocking. Dr. H. Anschütz-Kämpfe developed a gyroscopic compass to displace the magnetic compass, and this has been used with considerable success in warships, particu-

larly submarines in which the compass is entirely surrounded by a steel shell that acts as a shield for the magnetic needle and prevents it from being affected by the earth's magnetism. A gyroscopic stabilizer for airplanes was developed by Sperry in this country.

A process of dry galvanizing or "sherardizing" was discovered by Mr. Sherard Cowper-Coles. By this process iron and zinc can be coated with metallic zinc by the simple operation of bedding the piece in zinc dust in a drum and raising the temperature of the zinc dust to 500 or 600 deg. Fahr., which is some 100 degrees below the melting point of zinc. Dr. Schoop of Zürich invented a method of coating objects with metal in which the metal in pulverized state was projected against the object by a jet of high-pressure steam.

In 1907 E. G. Acheson discovered a method of producing deflocculated graphite.

Mr. H. A. Humphrey, a well-known English engineer, invented an internal combustion water pump.

Mr. David Roberts invented the caterpillar tractor which could haul heavy guns or other trailers over rough country.

The decade was particularly marked for developments in illumination, but this subject is fully covered in the special article on electricity.

Early in the decade Parsons of turbine fame brought out his "auxetophone," a device for augmenting talking machine sound reproduction by the use of compressed air, the air being admitted through a valve controlled by the needle, and hence taking the place of the reproducing diaphragm.

Fournier d'Albe invented an apparatus known as the "optophone," which renders light audible.

The closing year of the decade led to much activity in the development of war inventions. The Lewis machine gun invented by Colonel I. N. Lewis of the United States Army was widely used by the British and Belgians. This one-man gun uses part of the gases produced by the firing of the cartridge to furnish the power required to actuate the mechanism and the gun is cooled by air set in motion by the bullet. In 1915, gas warfare was introduced by the Germans.

1915–1920

As we come down to the present day it is increasingly difficult to pick out important inventions. Machines and processes that look very promising may turn out to be failures and an obscure invention that might easily be overlooked today may prove to be of epochal importance.

Most of the prominent developments of this period have to do with the war and their value was immediately tested. They are of such recent occurrence and so fresh in the minds of our readers that we need merely list them:

The Browning machine gun and Browning shoulder rifle were developed by John M. Browning after our entry into the war. There were important improvements in large guns, most notable of which was the German 75-mile gun with which Paris was shelled. Trench warfare led to the invention of various types of trench mortars. Gas warfare was highly developed and all manner of poisonous and suffocating gases were discovered and fired in shells by the opposing armies. Battles were carried on at night under the light of flares and star shells. The most notable invention on land was the tank, a development of the caterpillar tractor which was a factor in overcoming machine gun nests.

On the sea the submarine was highly improved. The Germans built a number of mine-laying submarines. To overcome the submarine the depth bomb was invented and the hydrophone was developed by which the presence of a submarine could be detected by sound.

Since the war a very promising development in thermo-dynamics is the Still engine. In this engine the piston is driven in one direction by internal combustion of fuel and in the other direction by steam generated by the combustion in the cylinder. The efficiency of this engine rises as high as 41 per cent, while the highest efficiency of any other prime mover is only 36 per cent, this figure having been attained by a Diesel engine. The inventor is William Joseph Still.

The most remarkable machine of this period is the type reading optophone—an instrument by which the blind can read ordinary print. The inventor is Dr. E. E. Fournier d'Albe. A complete description of this instrument is to be found in the current issue of the SCIENTIFIC AMERICAN MONTHLY.

DeForest transmitter vacuum tube alongside a telephone to show relative size

The Current Issue of the Scientific American Monthly

ON account of the critical paper situation, the SCIENTIFIC AMERICAN MONTHLY was obliged to suspend publication for the months of August and September. Publication, however, is resumed with the October issue and we hope that there will be no further interruptions. The contents of the October number are exceptionally interesting.

One of the most marvelous instruments of the present day is an electrical reader by which the blind are enabled to read any ordinary printed matter. The "type-reading optophone," as it is called, is the invention of Dr. E. E. Fournier d'Albe. The inventor's own description of the machine is given in the current MONTHLY with photographs and diagrams illustrating the operation of the apparatus.

"The World's Supply of Energy" is the title of an exceedingly interesting paper by Dr. Svante Arrhenius, Ph.D., M.D., D.Sc., LL.D., who discusses the problem that we shall have to face when our supplies of coal and oil are exhausted. In this connection, another article entitled "Setting the Tides to Work" will be found of interest.

Dr. Caroline Rumbold, pathologist of the Bureau of Plant Industry, U. S. Department of Agriculture, tells of a new method of giving medicine to trees and shows how the chestnut blight is being fought by injections of curative chemical solutions.

If America is to hold its place in the commercial world, we must pay more attention than we have in the past to geographic training. This subject is discussed by J. Paul Goode, Professor of Geography in the University of Chicago.

A very important article is one entitled "The Breaking Up of Nitrogen" by Dr. E. Regner, in which he shows how the theory of the transmutation of metals is verified in a startling manner by modern research.

In the March issue of the SCIENTIFIC AMERICAN MONTHLY, there was an account of an ultra rapid cinematograph which would take pictures at the rate of 20,000 to 50,000 photographs per second. In the current issue of the MONTHLY, further information on this subject is given, with actual photographs of the flight of revolver bullets, birdshot from a shotgun and a 37 mm. shell.

Dr. K. Seibel writes on the interference of X-rays, in which the vibratory nature of Roentgen rays is proved by an ingenious experiment.

There is an interesting article on the miniature textile mill of the U. S. Bureau of Standards by Herbert T. Wade.

Altogether there are twenty-six articles in the current MONTHLY, together with a large number of notes and the usual departments of the National Research Council, the Bureau of Standards, Progress in Mechanical Engineering, Mining and Metallurgy, Electricity, Chemistry and General Science.

Asbestos in America

AN asbestos claim has been located in Apache County, Arizona, according to an authoritaive investigation by the U. S. Bureau of Mines. The deposit, seemingly extensive in its reach, has been traced for more than 20 miles. Vein exposures are so pronounced that the passerby, in the absence of miner's tools, can pick from the wayside a ton or more of the crude product, broken down from the prominent veins.

A specimen of the deposits examined by government scientists revealed characteristics of the typical Arizona asbestos. The material is strong, flexible, silky and found in cross-fiber veins with a grain length of one to one and one-quarter inches, while fiber two and one-half inches in length has been reported. Specimens examined evidence effects of surface weathering, a better quality of asbestos doubtless being obtainable by development work.

Considering the shortage of crude asbestos in this country, it is regrettable that the Government forbids the mining of asbestos deposits on unallotted Indian lands, where this discovery has been made. The Office of Indian Affairs has recommended to Congress the lifting of the ban which now prohibits the development of unallotted Indian lands for the purpose of mining asbestos, coal, oil and gas.

The U. S. Bureau of Mines is in receipt of information from Genoa, Italy, of the manufacture of a new asbestos product. The fresh undertaking is the making of asbestos pipes of 85 per cent Portland cement and 15 per cent asbestos fiber of shingle stock grade. The pipe is constructed in varying sizes, from 4 to 12 inches in diameter and in lengths up to 12 feet. The thickness increases with the size from one-half inch for the 4-inch pipe to 15/16 for the 12-inch size.

Four machines are in operation by this foreign enterprise, each unit having a capacity of 3,000 feet of pipe every 24 hours. The finished product is seasoned under water for 90 days before used. Lighter in weight than iron pipe, among the virtues claimed for the new asbestos product is that it will stand up under a maximum pressure of 450 pounds to the square inch. It is acid-and-corrosive-proof.

Pin-making machine invented by John Ireland Howe in 1835

Taking into consideration the excessively high cost of Portland cement in Italy, due to the soaring prices of coal, it is claimed that the expense of manufacture is not more than one-third of the net selling price of coal. The same Italian enterprise is likewise making wall tile of similar composition to the asbestos pipe. It is decorated with imitation rock surface patterns and figured designs. Although a better glaze is desirable, the material is attractive, less brittle than porcelain tile, and because of the comparatively cheap cost of production offers an inviting field for development. Owners of the Italian patent desire to grant manufacturing rights for these products to an American firm on a royalty basis. Samples of the tile are on public exhibition at the Bureau of Mines, Washington, D. C.—By *S. R. Winters.*

A New Process to Improve Steel Making

AN improvement of the acid Bessemer steel process which aims to reduce the cost of making steel and to decrease the possibility of low quality steel in the process has been recently invented by a member of the department of mining and metallurgy at the University of Wisconsin.

The purpose of the invention is to use basic material for the lining of the Bessemer converter instead of the acid lining now used in order to prevent corrosion of the interior of the converter and to reduce the amount of air pressure and engine power now required. With the basic lining, composed of lime, magnesite, dolomite, oxid of iron, or the like the inventor believes it will be possible to use lower pressure and cut down the time of blowing about 30 per cent.

To prevent corrosion of the converter bottom the inventor proposes a number of different kinds of linings for various acid Bessemer converts and details the particular parts of the converter that require such a basic lining, while the remainder of the converter has an acid lining to resist corrosion by the acid slag. The invention is applicable to the bottom-blown type, side-blown type and other kinds of Bessemer converters operating on the principle of making steel by blowing air through a body of molten iron.

Quake-Proof Houses

EARTHQUAKES in Italy, America, and elsewhere, the great explosion at Silvertown, the alarming subsidences due to brine-pumping at Northwich, and various cases of settlement in unstable soils have sufficiently demonstrated the advantages of the "single-unit" action of the reinforced concrete skeleton system, says a British writer. Now that so much energy is being expended on the design and construction of dwelling-houses, and innumerable schemes are being submitted for approval by enthusiastic patentees, it is well that people about to build on clay soil, especially when the surface is hilly or undulating, should take into consideration the advisability of adopting the reinforced concrete skeleton as a safeguard against future troubles in the form of cracked walls, bay windows, porches and ceilings, constantly recurring damage to plaster cornices and wall paper, and frequent attention to the fit of doors in openings which vary in dimensions with the state of the weather. This is by no means a fancy picture, but fairly represents the effects of clay soil on houses of ordinary construction, the extent of the trouble naturally varying with local conditions. The monolithic reinforced concrete skeleton is a certain preventive of structural dislocations, and if the panels are fitted with brick curtain walls the building will possess all the advantages of one constructed in the ordinary way, without its shortcomings in respect of stability.

The proposed Hudson River Suspension Bridge, which may be adopted as a memorial to those who died in the war. Length of main span, 3,000 feet; height of towers, 650 feet; width of floor, 200 feet. Capacity: 16 tracks, an 80-foot automobile roadway, and foot passenger promenades

Civil Engineering

What the Man with the Transit and Level Has Done During the Past Seventy-five Years

IF we were called upon to name the technical profession which more than any other has been concerned with our modern industrial development, it would be safe to name that of civil engineering. For without the man with the transept and the level, it would have been impossible to weave over the continent of the earth its vast network of railways with its crossings of the rivers by bridge or tunnel, its vast retaining walls and embankments and its bold piercing of mountain summits by tunnels. This is said with no disparagement of the mechanical engineer, without whose multiplied activities the work of the civil engineer would have been greatly delayed and even in some cases indefinitely postponed, for his ingenious constructions have been always forthcoming to make possible the work which the civil engineer put through.

Manhattan Suspension Bridge across the East River. Length of main span, 1,470 ft., width of floor, 120 ft. Capacity: four two-track electric railways; a 35-foot roadway, and two 10-foot sidewalks

In a brief review of civil engineering during the past seventy-five years, we can do no more than touch lightly on the greater works which have been accomplished, and we shall confine ourselves in this review to the construction of long-span bridges, sub-aqueous tunnels, subways, canals, water supply and irrigation.

Bridge Engineering

The early development of American bridge engineering shows a wide divergence from that in Europe. When we passed from the wooden bridge to the steel bridge, the eye-bar type of construction quickly became the standard American type. The eye-bar truss showed the characteristics of great depth, long panels and a general standardization of details. We produced a type of bridge that was easy of construction and adapted to rapidity of work both in the shop and the field. European bridge engineers favored riveted construction. Their bridges were more shallow and more rigid, took more time for construction and erection and were more costly. When we came to build in the larger sizes, we turned increasingly to riveted work, with the result that the modern American bridge is a combination of the two systems.

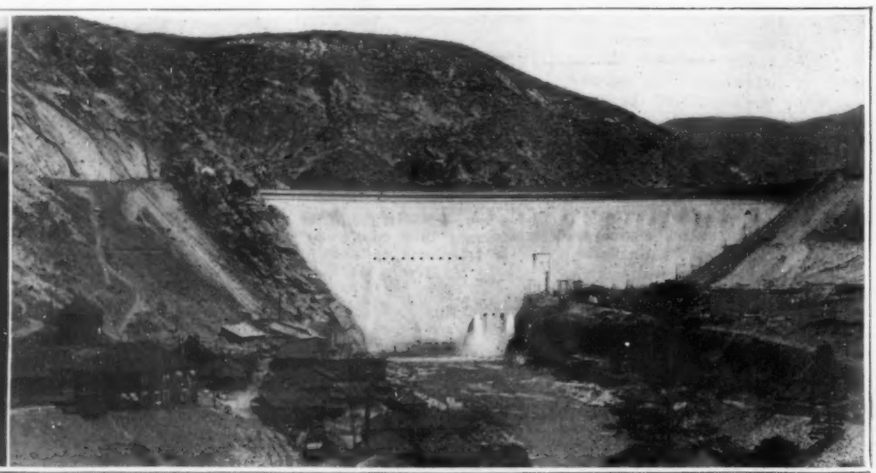
Among early notable bridges, mention should be made of Robert Stephenson's railway bridge over the Menai Straits, the crossing being made up of 8 rectangular plate-iron tubes of which four are 230 feet and four 472 feet in length. Of the same type was the celebrated Victoria Bridge across the St. Lawrence River, of 25 spans, each 244 feet in length.

It is in the construction of long-span suspension bridges that American engineers have won perhaps their greatest distinction. In the year 1855 Roebling built the Niagara suspension bridge of 821 feet span; and in 1874 commenced construction across the East River, New York, of the beautiful Brooklyn suspension bridge, with a main river span of 1,595 feet, which will forever be associated with his name. It is carried upon four 15-inch wire cables, and the work was opened in 1883. In all the world there was nothing approaching this structure in size at the time it was built. In 1902 the Williamsburg suspension bridge over the East river was opened. The central span of the bridge is 1,600 feet. A few years later the Manhattan Bridge with a main span of 1,470 feet and a floor width of 120 feet was put in service. The steel wire cables of this bridge are 20 inches in diameter. It carries, in addition to a main roadway and passenger walks, eight railroad tracks which are laid upon two decks.

After thirty years of waiting for a bridge to cross the North River, it now seems likely that work will be started shortly upon the great railway and vehicle bridge planned by Gustave Lindenthal, and that this structure, by means of suitable sculpture and bronze tablets, will be constituted a memorial to those

(Continued on page 350)

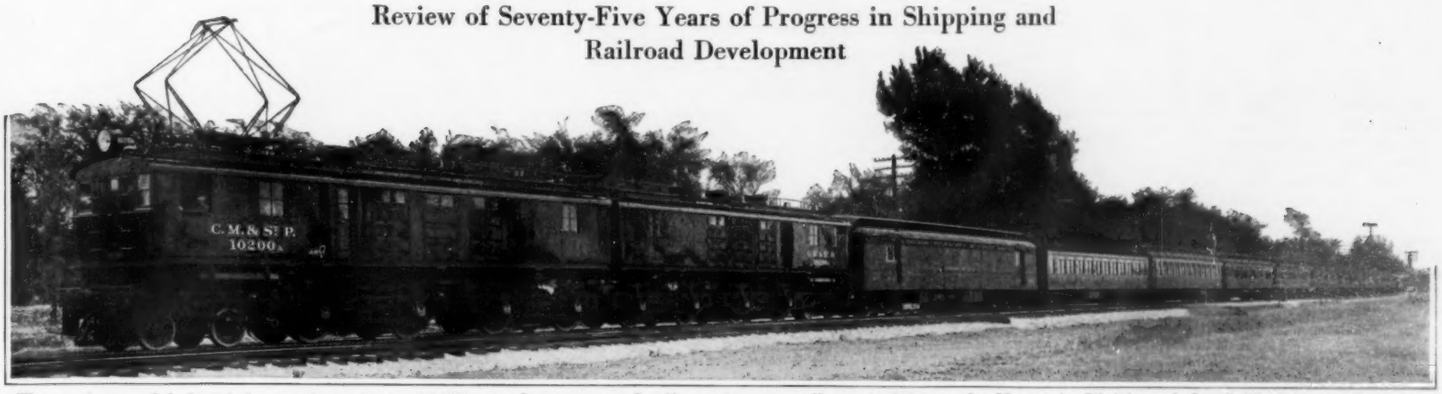
The twin locks, in three flights, at Gatun, Panama Canal



Arrowrock Dam across the Boise River. Height, 348.5 ft.; length, 1,060 ft. thickness at base, 240 ft. Capacity, 244,000 acre feet

Transportation by Sea and Land

Review of Seventy-Five Years of Progress in Shipping and Railroad Development



The most powerful electric locomotive extant, of 4,200 max. horse-power, hauling a ten-car pullman train over the Mountain Division of the C. M. & St. P. Railway

THERE is a sense in which it may be said that the story of human progress is the history of man's struggle to overcome the inertia of things. This is true in the domain of intellect and morals, and it is doubly true of the material world. Who shall set a limit upon the benefits that have come to us from the development of transportation? Can we not truly say that the material advance of civilization is to be measured by the facilities of the human race for travel? Certainly this holds good of the later centuries, particularly of the nineteenth and of the twentieth.

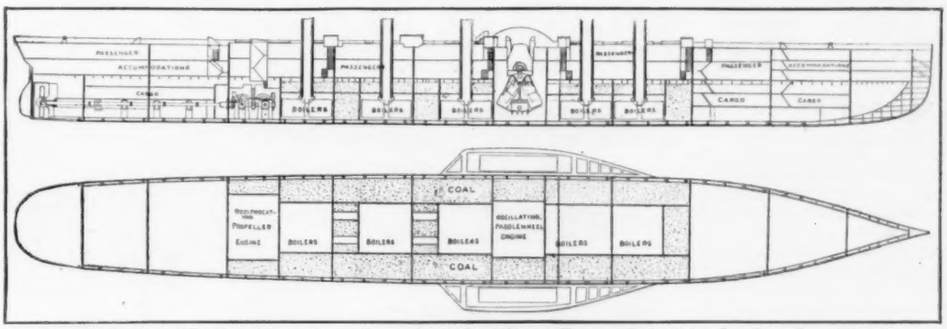
The present review of this subject is concerned with the seventy-five years covered by the unbroken publication of the SCIENTIFIC AMERICAN, and one does not proceed very far in his study of the subject before he realizes that there has been more development of transportation since 1845 than in all previous recorded history. In that early day the steam-driven ship was beginning to be a competitor of the sailing ship.

The Beginning of Steam Navigation

Twenty-five years before the SCIENTIFIC AMERICAN commenced publication the sailing ship, "Savannah," equipped with auxiliary paddle-wheels which could be taken inboard, had crossed from Savannah, Georgia, to Liverpool in twenty-eight days, having made use of her steam power for about three and one-half days of the voyage. The "Savannah" was an attempt to apply to ocean navigation the work of Symington, whose steamboat, the "Charlotte Dundas," in 1802 had towed two 70-ton vessels successfully for twenty miles on the Forth and Clyde Canal, and the better-known work of Fulton, who in 1807 built the famous steamboat "Clermont," the forerunner of the American river steamer of today which, on its trial, ran a distance of 150 miles in thirty-two hours. Later, in 1833, the "Royal William," propelled entirely by steam power, crossed the Atlantic from Quebec. Then came the "Sirius" and the "Great Western," the latter being the first steamship designed especially for the Atlantic trade. Both of these boats reached New York on April 23d, 1838.

The voyage of the "Sirius" and the "Great Western" proved that transatlantic steamship navigation was thoroughly practical, and several lines that were destined to become famous, such as the Cunard Line, the Inman Line, the Collins, an American line, and the Anchor and the Allan Lines, began their active service.

All of these early boats were equipped with side wheels and were driven by side-lever engines, which were practically a modified form of the engine developed by the great Watt. The American vessels used the overhead beam engine, and this was destined for many years to be the characteristic type both for ocean and river service. Steam pressures were very low, running from three to five pounds, and seldom exceeding ten pounds above atmospheric pressure. So bulky were the engines that they occupied nearly one-third of the length of the ship. At about the same time, experimental work was begun by Ericsson in America and by Smith and Woodcroft in England on the introduction of the screw propeller. The first British steamship to use this form of propulsion was the "Archimedes." The British admiralty, after competitive tests between the paddle-wheel and propeller, launched the "Rattler," in 1843. It was so successful that many other screw-driven naval vessels were built.



Longitudinal and horizontal sections throughout the "Great Eastern" (1858), showing the elaborate system of sub-division

Two years before the appearance of the SCIENTIFIC AMERICAN, that great engineer, Brunel, built the "Great Britain," which in size, construction and equipment marked a great advance over contemporary practice. She was 322 feet over all, and was remarkable for being built entirely of iron, with iron masts and wire rigging. Furthermore, she was divided into five, separate, thoroughly water-tight compartments.

The first American steamer to be built especially for the Atlantic trade was the "United States," of 2,000 tons. She was the first merchant steamship constructed for naval use as a cruiser, provision being made for arming her with two tiers of guns. Then came such American ships as the "Washington," of 1,700 tons, the "Hermann," of 1,800 tons, the "Franklin," of 2,400 tons, and the "Humburg," of 2,850 tons. Conspicuous mention should be made here of the Cunard Line, whose first ship, the "Britannia," one of four built specially for the passenger and mail service, made her maiden trip from Liverpool to Boston in July, 1840. During the decade 1840-1850, the control of the steamship traffic between America and England was practically in the hands of the Cunard Company, and as a result of the inrounds which they were making upon the trade of the celebrated American clippers, an American company was formed by Mr. E. K. Collins, of New York, to establish a rival line of American steamers. Four ships, which were intended by their size and speed to surpass the Cunarders, were built with all possible dispatch, and in 1850, the American company had four ships afloat which in speed and comfort were a distinct advance upon anything afloat. These ships, in the year 1851, lowered the time from New York to Liverpool to nine days, twenty hours, and fifteen minutes. The engines were of the side-lever, condensing type, and the boilers carried about seventeen pounds of steam. The best day's run of the "Arctic" was 320 knots at a speed of 14 knots. The Collins venture, opening so auspiciously, was destined to meet with a series of disasters, and these, coupled with the rivalry of the Cunard Company, who, in 1855, launched the "Persia," of fourteen knots' speed, and the withdrawal of the Government subsidy, brought about finally the dissolution of this famous company.

"United States," first American ocean-going steamship. Designed especially for the Atlantic trade

The Famous Clipper Ship Era

Just here something should be said about the wonderful era of the American clipper ship, which lasted for a quarter of a century or, say, from 1845, when there was a demand for a more rapid delivery of tea from China, down to the opening of the Suez Canal and the coming of the large steam-driven ship. The high premium that was

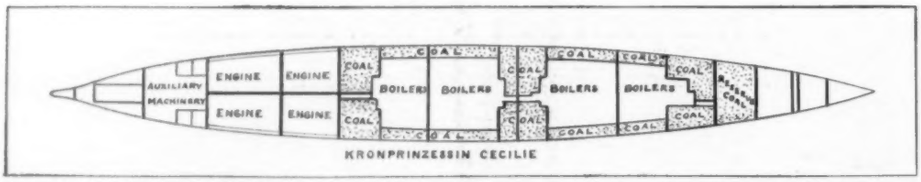
paid for the first consignments of tea led to the building of finely modeled, heavily sparred, square-rigged ships, out of which the Yankee captains got every possible knot of speed. Instead of avoiding these men courted the gales of wind, if they were favorable, and some astonishing day's runs and hourly speeds were attained. These records are authentic and anyone who loves the sea and ships will find it all written down most entertainingly in "The Clipper Ship Era," by Capt. Arthur H. Clark, one of the few survivors of that notable time. Mr. Clark copied these records from the original log books of the skippers, which he found preserved in archives of shipping companies, in museums or elsewhere.

To take one or two instances. The "Flying Cloud," during a passage of 89 days from New York to San Francisco, sailed for four consecutive days 284, 374, 334 and 364 miles—an average speed of 13½ knots. The "Sovereign of the Seas" sailed before heavy westerly gales on four successive days 396, 311, 411 and 360 miles—an average hourly speed for 1,478 miles of 15½ knots. During her great run of 411 miles in a sea day of 23 hours, 18 minutes, she averaged 17 2/3 knots. The highest recorded speed was made by "The Lightning," 244 feet in length, in 1854, during a trip from New York to Liverpool. The log entry for March 1st reads, "Wind south. Strong gales—hove log several times and found ship going through water at rate of 18 to 18½ knots; lee rail under water and rigging slack. Distance run in 24 hours, 436 miles."

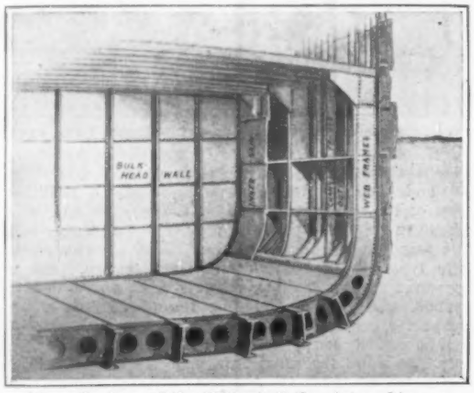
It was the delight of the skippers of those days, when they sighted a steamship ahead, to close in to within hailing distance, and sweep by the wallowing, smoking sidewheeler, while her steerage passengers jeered in derision at the "tin kettle." Twenty-five years passed before a steamship, the "Arizona," equalled the speed 18 knots achieved by the "Lightning."

The Safest Ship Ever Built

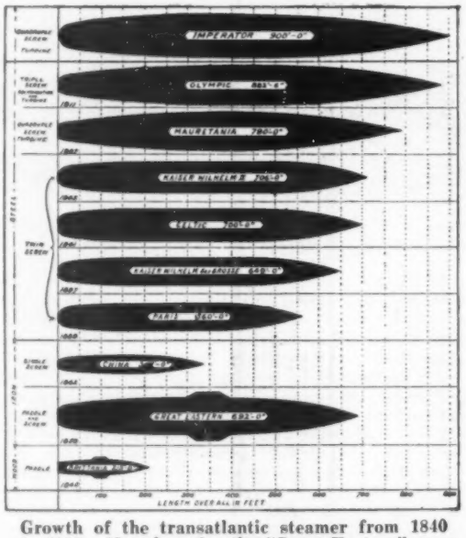
No review of the development of the steamship would be complete without mention of the "Great Eastern"—unquestionably the most remarkable ship ever constructed. In size, strength of construction and safety against foundering, and also in accommodations for the passengers, she was many decades ahead of her time. It was nearly half a century before her length of 680 feet was exceeded by the "Oceanic," of 705 feet. She was built by a company which was formed in England in 1853 to build a steamship which could carry enough coal to make the round trip to Australia and back at a speed of eighteen knots. That great engineer, Brunel, was entrusted with the design. Like "Britannia," his first iron, screw-propelled ship, the "Great Eastern," showed the inventive genius of her designer. Great attention was paid to the safety provisions. She was built with a double hull which extended ten feet above the water line and was closed in by an iron, water-tight deck. She had nine water-tight bulkheads, which were carried up to the top deck, thirty feet above the water line, and this top deck was built of iron and was double, with a space of two feet between the two decks. Longitudinal bulkheads were carried through the machinery and boiler spaces, and it is pretty safe to say that the "Great Eastern" would have survived the iceberg collision which sank the "Titanic." She was driven both by paddle wheels and propeller, a set of oscillating engines operating the former and an independent set of horizontal engines driving the propeller. She made her maiden trip from Southampton to New York in 1860, when her highest speed was 14½ knots. The failure of the "Great Eastern" was due to the fact that sufficient passengers and freight could not be secured to make her profitable. Her best work was done in laying cables, the first Atlantic cable having been laid by this ship in 1866. In 1888 she was sold for old-iron-and-broken-up at Liverpool. The "Great Eastern" remains today the finest example of a safe ship. Gradually, in response to the demands of the steamship companies for economy of construction, the various safety devices embodied in her have been eliminated. Of the double hull, only the double bottom survives. The water-tight bulkhead deck has disappeared, and it has been lowered from thirty feet above water level in the "Great Eastern" to ten or twelve feet in most modern ships. Only in the Navy has the safety construction of the "Great Eastern" been preserved and amplified. The protection due to subdivision was proved by the ability of warships to endure terrific punishment by gun and torpedo.



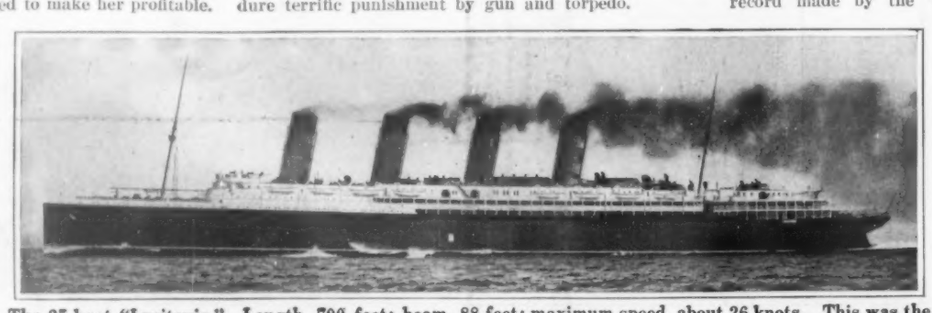
This shows the excellent sub-division of the former German steamship, "Kronprinzessin Cecilie" (now "Mount Vernon") which saved the ship when she was torpedoed during the war



After the loss of the "Titanic," the sister ship was improved by carrying the floor plating up the inside of the web framing so as to provide a double skin—a suggestion first made in the book, "An Unsinkable Titanic"



Growth of the transatlantic steamer from 1840 to 1912. Note how far the "Great Eastern" was ahead of her time. She was not exceeded until the advent of the "Oceanic" in 1899



The 25-knot "Lusitania." Length, 790 feet; beam, 88 feet; maximum speed, about 26 knots. This was the first of the fast, turbine, ocean liners

The screw propeller was now rapidly driving out the paddle wheel, the "Scotia," of 3,807 tons being the last of the paddle-wheel ships built for the Cunard Line. She was the first to make the transatlantic passage in less than nine days. To the old Inman, later the American Line, is due the credit of bringing the passage below eight days with the screw steamer, "City of Brussels," of 3,747 tons. A memorable year was 1871, which saw the birth of the famous White Star Line, whose "Oceanic" and "Adriatic" introduced many features designed to increase the comfort of travel. The first ship to bring the passage below seven days was the "Alaska" of the Guion Line, and in 1889 the "City of Paris" reduced the time to less than six days. The last of the large liners to be driven by a single screw was that fine pair of ships of the Cunard Company, the "Umbria," and the "Etruria," which made their appearance in 1884. They were 525 feet in length and of 12,190 tons' displacement. Their single screw engines, the largest of their kind ever put into a steamship, indicated 14,500 horse-power, and the "Etruria" maintained a speed of 19.6 knots for the whole trip across the Atlantic.

To the Inman and International Company stands the credit for producing in the "City of New York" and "City of Paris" the first twin-screw liners, driven by triple expansion engines. These fine ships of 10,500 tons and 20,000 horse-power were a great advance upon anything built or planned in 1889, and it is notable that, together with the "St. Paul" and the "St. Louis," built by Cramp, of Philadelphia, which entered active service in 1895, these ships are still doing good work on the Atlantic route.

Contest for Blue Ribbon of the Atlantic

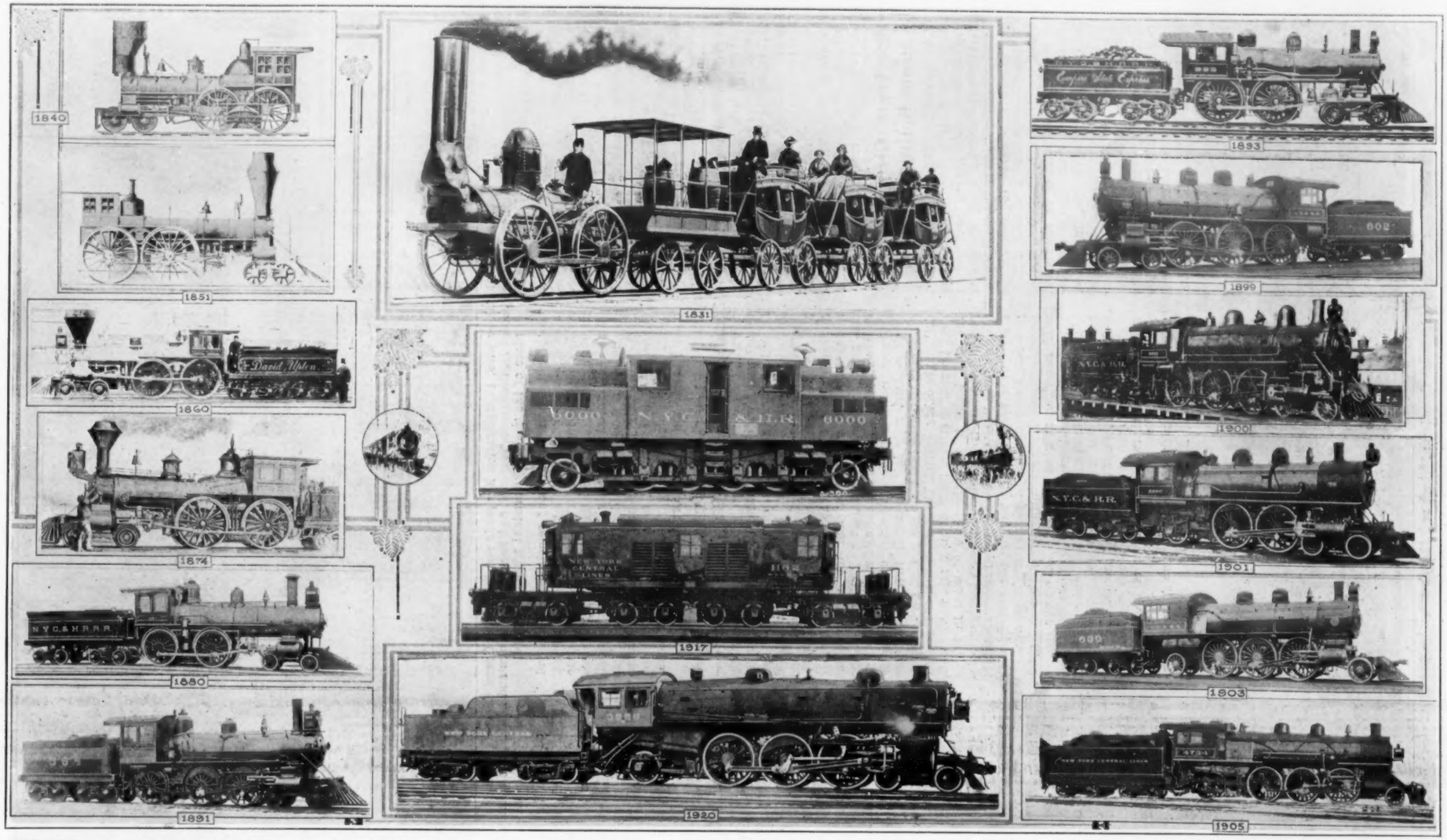
It is impossible within the limits of this article to follow in any detail the subsequent development of the transatlantic liner. The Cunard Company took the lead again in 1893 with the "Lucania" and "Campania," the first ships to exceed 600 feet in length. With 30,000 horse-power the "Lucania" crossed the Atlantic at a speed of over 22 knots.

Then, in 1897, the Germans, with the "Kaiser Wilhelm der Grosse" won the laurels. This was the first of the four-funnelled steamships of which the German companies, and later the British, were to build so many. In 1899, the White Star Company brought out the "Oceanic," 705 feet in length, the first modern ship to exceed the "Great Eastern" in length.

The Hamburg-American Line then made a bold bid for the blue ribbon of the seas with the "Deutschland," which, with 37,500 horse-power, maintained an average of 23.5 knots, thereby winning the record from the North German Lloyd, which replied by building the 707-foot "Kaiser Wilhelm II," which, with about the same speed, captured the transatlantic record.

The Germans had held the blue ribbon of the Atlantic for a whole decade when, in 1906, the Cunard Company built the "Lusitania" and the "Mauretania," 790 feet in length and of 44,500 tons deep-draft displacement. They were driven by turbines of 70,000 horse-power, operating four propellers, and they recovered the speed record from the Germans, the "Mauretania," crossing at an average speed of 26.06 knots per hour. This record was to stand for some twelve years, and in fact, still stands today, although it will probably be bettered by the "Aquitania," which has shown a great increase of speed since she was equipped with oil burners. On a recent trip to the eastward, she covered the last 129 miles to Cherbourg at the average speed of 27.40 knots; hence, it is probable that when she is shaken down, she will surpass the record made by the "Mauretania." Following the "Lusitania" and the "Mauretania," in the extraordinary growth in size of ocean liners, came the "Olympic" and "Titanic," 883 feet in length and displacing 52,000 tons. These vessels were furnished with magnificent accommodations, including gymnasiums, a swimming pool, sun parlors and all the conveniences of a modern hotel. Their speed was about 23 knots. Then followed the "Imperator," of the Hamburg-American Line with her length of something

MILESTONES IN THE DEVELOPMENT OF THE AMERICAN PASSENGER LOCOMOTIVE



THERE were other locomotives before the "DeWitt Clinton," to be sure; but for our purposes it is well to begin with that historical train in giving a pictorial resumé of the development of the American locomotive. The "DeWitt Clinton" locomotive, built in 1831, was the second locomotive to be turned out by the West Point Foundry, and was put to work on the Mohawk and Hudson Railroad. By 1840 the American type locomotive, with four driving wheels and a four-wheeled swiveling truck, had made its appearance. The next illustration shows a locomotive of 1851 with a "cow catcher" or pilot. In the locomotive of 1860, the sandbox makes its appearance. It is interesting to note that locomotives of the Civil War period were highly ornamented, and were given names of railroad men, generals, presidents, and so on. This practice is still evident in the locomotive of 1874, which differs mainly in the matter of larger proportions for attaining still higher speeds. By 1880 the locomotive began to assume something like modern lines; indeed, locomotives of the type here shown are still in use on many of our smaller railroads and branch lines. The freight locomotive of 1891 has three sets of driving wheels, in order to insure better tractive effort for hauling the heavier trains then coming into use. In our locomotive of 1893 we have the famous "999," which broke the speed records of her day while drawing the Empire State Express. By 1899 we enter the era of large passenger locomotives, with three sets of drivers, and 1900 shows a further step in this direction. The locomotive of 1901 shows the debut of the well-known Atlantic type, with four coupled drivers, and a trailing truck under the cab. A six-coupled type of passenger locomotive is shown as the locomotive of 1903, as well as in 1905, each of these having a leading pony truck, and a trailing pony truck. On September 30th, 1906, the first electric train, drawn by the locomotive in the center of this group, left the Grand Central Station in New York City. By 1917 a still larger type of electric locomotive was introduced for hauling trains in and out of the New York terminal and for thirty miles out of the metropolis. The 1920 locomotive represents a modern Pacific type, with a leading truck, six coupled drivers, and a pair of trailers.

over 900 feet and a displacement of 54,000 tons. With 65,000 shaft horsepower she has made about 22½ to 23 knots. The next year, the fatal year of 1914, saw two other notable additions to the great Atlantic fleet in the "Vaterland," now the "Leviathan," 950 feet in length, and the "Aquitania," of 901 feet. The "Leviathan," when in good condition, can make 23 knots, and if she should be fitted as an oil burner, should make 24 knots or more. The "Aquitania" has been converted from coal to oil, with resulting additions as we have seen, to her previous speed.

Coming of the Big Freighter

Side by side with the development of passenger travel on the high seas, there has been an even greater development of freight traffic. For many decades the passenger ships did double duty, all of them carrying more or less freight; but gradually there was evolved a special type of ship of great cargo-carrying capacity, deep and broad and of moderate engine power. In size these ships have shown a development comparable to that of the fast ocean liners, the capacity going up to 5,000, 10,000 and 20,000 tons and over, in the most modern examples. A combination of the large freight and passenger vessel is seen in the so-called "Express" ships, which by keeping down the speed to 15 to 17 knots are able to carry a large tonnage in the hold and provide comfortable and extensive passenger accommodations on one or more superstructure decks amidships.

The latest development and one that is destined to have a profound effect upon ocean transportation is the use of oil, either as fuel in place of oil in steam-driven ships, or directly in the cylinders of internal combustion motors. The latest application to the "Olympia" and the "Aquitania" has raised the speed and greatly reduced the cost of operation of these famous ships. The only limitation upon the use of the internal combustion motor is the size of the individual cylinder that can be used to advantage.

These two photographs show what electrification has made possible at the Grand Central terminal. The tracks were lowered and roofed in, the streets restored, and fine office buildings and hotels have taken the place of the unsightly terminal tracks and yard

Seventy-five Years' Growth of the Steam Railroad

BECAUSE of our comparative isolation from the rest of the world, particularly during the early years of the development of our railroad system, the American railroad has marked characteristics which distinguish it as regards its track, rolling stock and general equipment, from the railroad systems of the rest of the world. These differences were due to several causes, chief among which were the comparative scarcity of our population, the great distance to be covered in those early years, the scarcity of capital and the demand for cheap and rapid construction. In Europe, with its denser population, the completion of a new railroad found passengers awaiting it on every platform and freight in every freight shed. In Europe the railroads followed the population; but in America they preceded it. Our early constructions were essentially pioneer railroads. They were built rapidly and cheaply, and were thrust out sometimes a thousand miles or more in advance of the oncoming tide of pioneer settlers. It was impossible, if the work was to be done within a reasonable time, to build our early railroads in the substantial and costly way that characterized the European work. We had to cut according to our cloth, if we may use that figure of speech, and leave the work of reconstruction to a later day when the increase of population, industry and commerce should make possible the inevitable rebuilding.

Low Cost of the Early Railroad

In accordance with this policy, in locating a new railroad, the engineer avoided heavy cuttings and costly tunnel work; which meant that these early lines must be full of curvature and contain many heavy grades. Fortunately, the problem of bridging was simplified by the extent and number of our great forests. The Howe Truss timber bridge and the many-storied trestle carried our railroads cheaply and expeditiously across many a great river and the deep chasms and ravines of broken, mountainous country. In the days when the SCIENTIFIC AMERICAN made its first appearance, railroad track in America consisted of forty to fifty-pound rails laid on small ties, which more often than not were laid upon the graded ground without the use of any ballast. The introduction of Bessemer steel brought a stiffer, more durable and harder rail, and steel began to take the place of wood in bridge construction. As traffic grew and funds became available, the early lines were relocated and heavy mountain grades were eliminated by piercing the summit with tunnels. Heavy grades and sharp curvatures were reduced, extensive ballasting was undertaken and gradually American railroad track, at least on our leading roads, was brought up to the level of the best European practice. From the 40-pound railroad of 1845, we have gone up to the 125-pound rail of 1920; and from a single track laid upon the graded ground, our trunk lines have gone up to four-track roads bedded upon from eighteen to twenty-four inches of broken stone ballast.

How many readers of the SCIENTIFIC AMERICAN are aware that practically the whole of our railroad system, totalling some 260,000 miles, has been built during the life of this journal? For it is a fact that in 1845 there was in the whole United States only 4,633 miles of railroad, consisting of a few disconnected lines in the Atlantic and Southern States and in the Middle West. In that year the Eastern railroads were just beginning to creep across the Alleghenies into the Mississippi Valley. Taking the growth of the system by decades we find that from 1845 to 1855, our railroads grew from 4,633 miles to 18,374 miles. By 1865 the total was 35,085 miles, and ten years later, 74,096 miles. In 1885 it had risen to 128,320 miles, and by 1895 to 180,657 miles. At the opening of the present century, the 200,000-mile mark had been passed, and today the system has grown to about 260,000 miles.

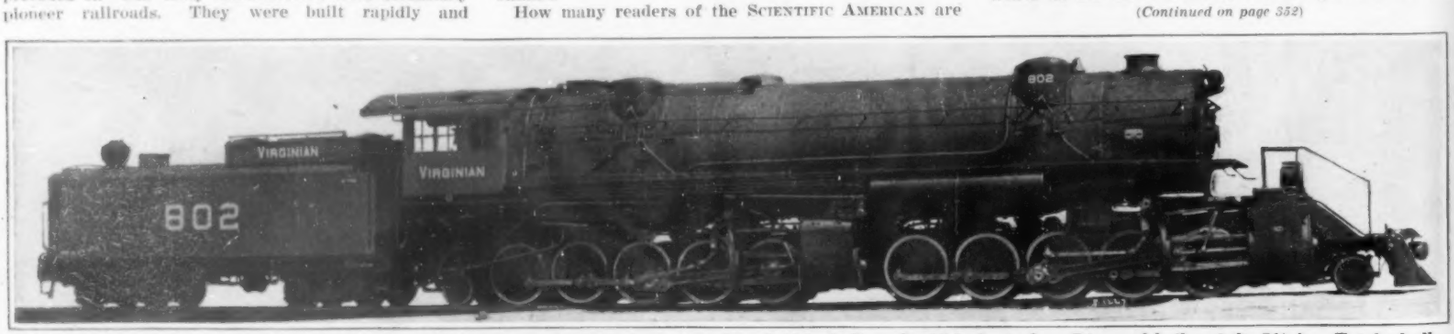
Opening of First Transcontinental Road

A red-letter day in the course of this progress was May 10th, 1869, when the first transcontinental road, the Union Pacific, was completed. The American passenger car, a distinctive type, with its long body mounted on swivelling trucks, was patented in 1834; and ten years later, when the SCIENTIFIC AMERICAN made its first appearance, it had come to be the typical American car. In those days it was a small and crude affair—forty to fifty feet long, lighted by oil lamps and warmed in the winter by wood-burning stoves. The improvements have been in the direction of comfort and safety. The oil lamp gave place to Pintsch gas, and steam taken from the engine replaced the dangerous wood or coal stove. The final development was the elimination of wood in favor of steel car construction, a change which has greatly reduced injuries and death due to collision and derailment. Another notable year was 1864, when Pullman brought out his first sleeper and thus led the way in a system of night travel which has become universal. Among all the inventions that have promoted speed and safety on the railroads, first place must be given to the automatic airbrake and block signal system. The airbrake, named after its designer, George Westinghouse, Junior, was first put into service in 1868-69. By this system, the engineer can set the brakes on every car and on his own engine by the manipulation of a small lever, and should the train break apart, the brakes will automatically set themselves. The automatic brake has been continuously improved, as will be seen by the following comparison. In 1890, a 280-ton train running at 60 miles an hour could not be stopped in less than 1,000 feet; but in 1915, a train weighing 950 tons and moving at 60 miles an hour, if equipped with the brake system of 1890, could be stopped in about 1,760 feet; while with the present improved electro-pneumatic Westinghouse airbrake it can be stopped in 860 feet.

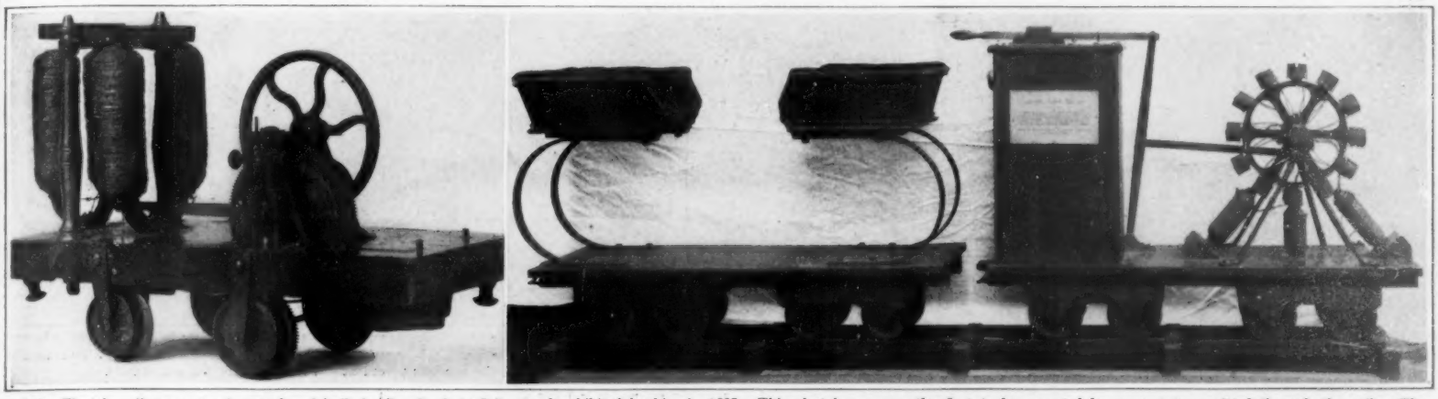
Block Signal and Automatic Stop

The greatest safeguard against railroad collision, the block signal, was developed mainly in Great Britain, where as far back as 1890, over 98 per cent of the

(Continued on page 352)



"The Virginian"; most powerful steam locomotive in existence. Cylinders: 30-inch and 48-inch diam. by 32-inch stroke. Diam. of boiler, 8 ft. 7⅛ in. Total of all heating surface including superheater, 10,725 sq. feet. Tractive power: compound, 147,200 pounds; simple, 176,600 pounds



Left: Electric railway motor invented and built by Dr. Gardner Colton and exhibited by him in 1837. This electric car was the first to be operated by current transmitted through the rails. The four electro-magnets served to actuate a rocking armature, which movement was transmitted by means of a gear to a pair of wheels. Adjustable contacts regulated the pull of the magnets. A flywheel aided in evening the reciprocating action of the armature. *Right:* Electric motor car and trailer built by Moses F. Farmer and exhibited by him in 1847 to demonstrate the feasibility of electric passenger carriers. The construction of his motor is quite obvious in the illustration

Two of the pioneer electric railways from which have descended the electric street cars and electrified railways of today

Seventy-Five Years of Applied Electricity

From the Telegraph of 1845 to the Radio Station of Today with a Range of Twelve Thousand Miles or More

ELECTRICITY has long been known to the scientist and experimenter, but its practical application is only of relatively recent date. Indeed, one year before the SCIENTIFIC AMERICAN was founded Morse opened his experimental telegraph line between Washington and Baltimore. That was in 1844. And telegraphy, at that time, represented the only practical application of that great and mysterious force which we call electricity.

Yet one thing is certain about applied electricity, and that is its rapid development. Following the advent of the Morse telegraph, inventors in many parts of the world set to work putting electricity to all kinds of use. In fact, the whole story of applied electricity is one of almost countless inventors in many different countries striving for the same ends; of simultaneous and identical inventions by widely separated inventors; and of developments whose origin it is difficult to trace because of the multiplicity of separate contributions entering into them. And so this story must perforce devote itself to the better known men who have done much to make electricity what it is today, without mention of many other contributors to the art whose names and achievements cannot be stated in detail for want of space.

From Plunge Battery to Dynamo

The past seventy-five years have witnessed the development of applied electricity from the plunge battery of the laboratory bench and schoolroom demonstration to the huge turbo-generator units of today, which furnish power for driving our electric railroads, turning the wheels of our factories, lighting our homes and business places, furnishing heat for cooking a meal or for producing carborundum in the electric furnace, and so on. In fact, applied electricity would still be in its infancy were it not for the almost unbelievable strides made in the generation, control and distribution of electric energy.

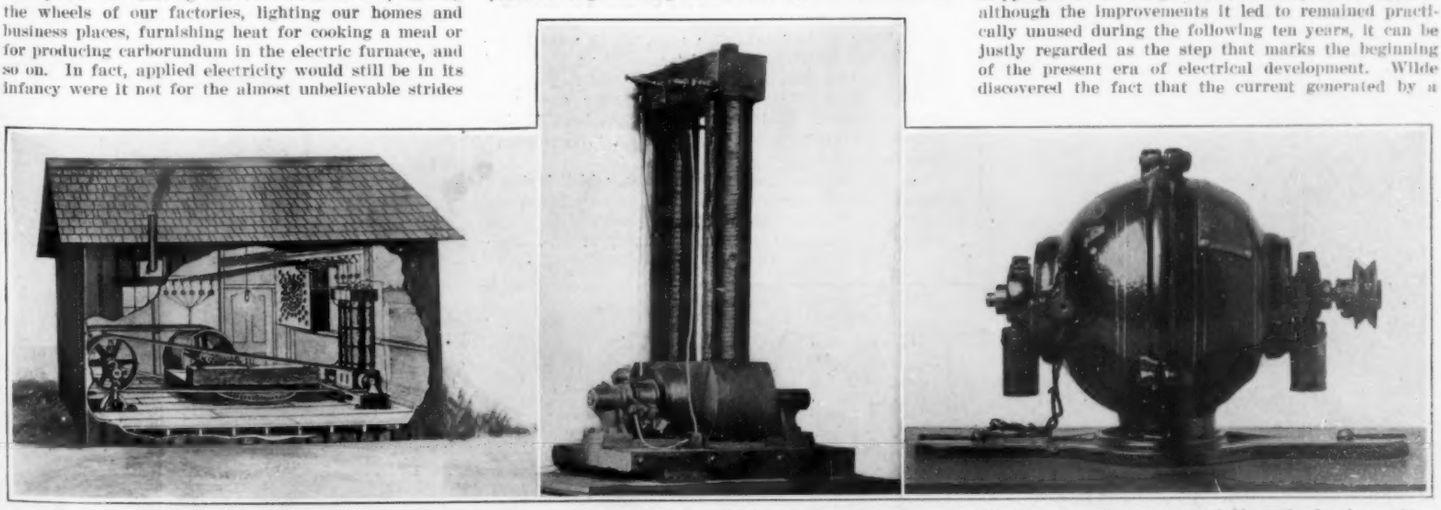
From 1850 to 1875 great advancement took place in the way of development of electric theories, and the demonstration of the laws that govern electro-magnetic actions. Since 1875 the progress has been more in the expansion of theoretical knowledge, and this is just contrary to the general impression in relation to the subject. Anyone who has doubts as to the correctness of this statement, however, can have them dispelled by a careful study of the electrical literature of the period. In the early seventies, for instance, Prof. James Clerk Maxwell brought out a masterly treatise on electricity and magnetism, in which practically every known law or principle relating to electricity and magnetism was covered.

The numerous effects of electro-magnetic action were extensively investigated at an early date, but their true relation to each other and to the other forces of nature were not properly understood until the doctrine of the conservation of energy was established upon a firm basis. Owing to this fact some of the most distinguished men of seventy-five years ago advanced views that were decidedly at variance with the facts and only served to assist charlatans in their efforts to defraud investors. So it followed that the development of the art was retarded materially until something of a very definite and authentic nature could be learned about electricity. It was this theoretical study that paved the way for the development which followed.

Soon men in various countries got to work on the problem of generating current in larger volume and at less expense than was possible with the usual battery which consumes zinc at an alarming rate for its small output. The electric motor in crude form already existed, and it was known that the motor, if made with permanent steel magnets for the field, would act as a generator of electricity if driven at a sufficiently high speed. Faraday, as far back as 1831, had demonstrated this method of developing current.

Although J. S. Woolrich constructed a generator of considerable size for the days of 1841, it was not until 1861 that anything of note was accomplished in the field of electric generation. In that year Holmes brought out a large machine of sufficient capacity to be used for arc lighting, or, more properly speaking, for furnishing current to one arc light. This machine generated current at much lower cost than the electric batteries, but its size was very great in comparison with the work it would do, and its construction was of such character as to be necessarily very expensive. Several other large machines of this type were designed and constructed during the next few years, but owing to their cost and bulkiness they did not meet with favor. The first direct current motor was built in 1860 by the Italian physicist, Antonio Pacinotti. His machine consisted broadly of an iron ring, suitably wound, which rotated between the poles of a horseshoe electro-magnet supplied with current from a battery. In the same year Pacinotti invented the commutator, which was reinvented by Gramme some years later at a time when the dynamo was waiting for just such an improvement.

In 1866 Wilde developed a machine which was the stepping-stone to the generator of the present day, and although the improvements it led to remained practically unused during the following ten years, it can be justly regarded as the step that marks the beginning of the present era of electrical development. Wilde discovered the fact that the current generated by a



Left: Earliest central station in United States, built for illumination purposes. *Center:* One of Edison's early bi-polar dynamos. This type of machine gave remarkable results for the requirements of pioneer electrical days, and motors of this same type have remained in use even to this day in isolated instances. *Right:* This motor has the distinction of being the first motor to be operated by current generated at Niagara Falls and transmitted some distance over lines

Three phases in the generation and application of electric current

Left: The original Morse receiver used on the Washington-Baltimore line in 1844, with clockwork mechanism for moving the paper type which recorded the electrical impulses in the form of dots and dashes. *Center:* Bell's original Centennial iron box receiver. During the exercises inaugurating the trans-continental telephone service between New York and San Francisco, Dr. Bell used a replica of this instrument with good results. *Right:* Bell's adjustable telephone of 1876. This was a receiver, and the ear was placed at the small end of the sound horn

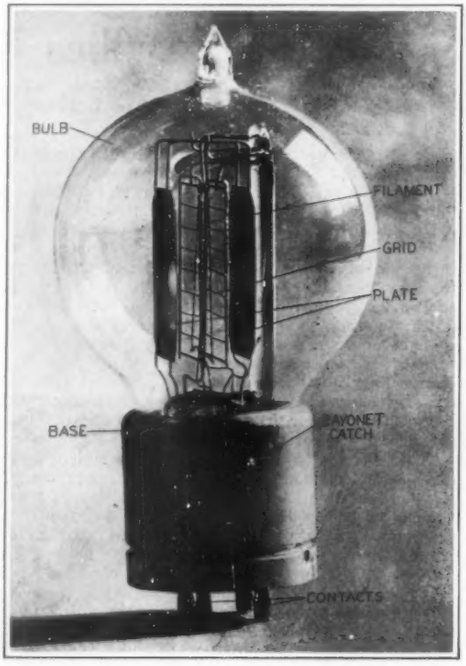
Pioneer days of telephony and telegraphy as reflected by typical apparatus

small magneto machine, if used to energize a powerful electro-magnet forming the field of a larger machine, would enable the latter to develop a current many times greater than that of the small machine. This discovery resulted in directing the attention of scientific men to the subject with renewed vigor. After a careful consideration of Wilde's work, the conclusion was arrived at that if a comparatively small machine could energize the field of a much larger one that would generate a current many times greater, it ought to be possible to use a part of the current of the large machine to energize its own field, and thus dispense with the smaller machine. But it was thought that the assistance of the small machine would be required to start the action. By actual trial it was found that the larger machine would start a current without assistance of the small one. And that was the basis of the present generator.

Refinement Follows Refinement

From 1866 to 1876 very little was accomplished in the way of practical development, but quite considerable in the way of improving the dynamo or generator. In the machine of Wilde and several others that immediately followed it an armature was used that gave pulsatory current. Gramme made an improvement in this direction by adopting a ring-shaped armature upon which the wire was wound in a great many sections, the ends of which were attached to a commutator of a corresponding number of sections. The result of this construction, known as the commutator, was to produce uniform current, and the former destructive sparking of the brushes was practically eliminated. Siemens, also, worked in this line and accomplished the same results by the use of a drum-shaped armature.

From 1876 on the development of the electric generator was accelerated. Edison turned his inventive genius to the problem of the generator and current distribution at about that time. Both Edison and Weston hit on the idea of the three-wire system of current distribution, thus making electricity available over a wide area at a low cost. In 1878 Charles F. Brush introduced his famous compound dynamos, at a time when Edward Weston's dynamos were also in the market. In 1880 Gaulard and Gibbs worked out a system of distributing alternating current at high ten-



The action of the vacuum tube is still a matter of conjecture. Generally, its action is said to be due to the emission of a constant stream of electrons from the heated filament to the plate or plates, regulated by current on the grids

Typical vacuum tube and its essential members

sion. They utilized induction coils, which were transformers, but which they called "secondary generators." This early transformer was one of the first steps which rendered it possible to transmit electric energy to great distances. Déri and Zipernowsky, in 1882, improved upon this work, and the term "transformer" came into being.

But the modern transformer system, which involves transmission from a station of high potential and the reduction of the potential in the secondaries of transformers, was worked out in a small way at the Franklin Institute in Philadelphia in 1879, by Prof. Elihu Thomson. In fact, all the way through the development of electric generation, distribution, and application we come across the extensive and invaluable work of Prof. Thomson.

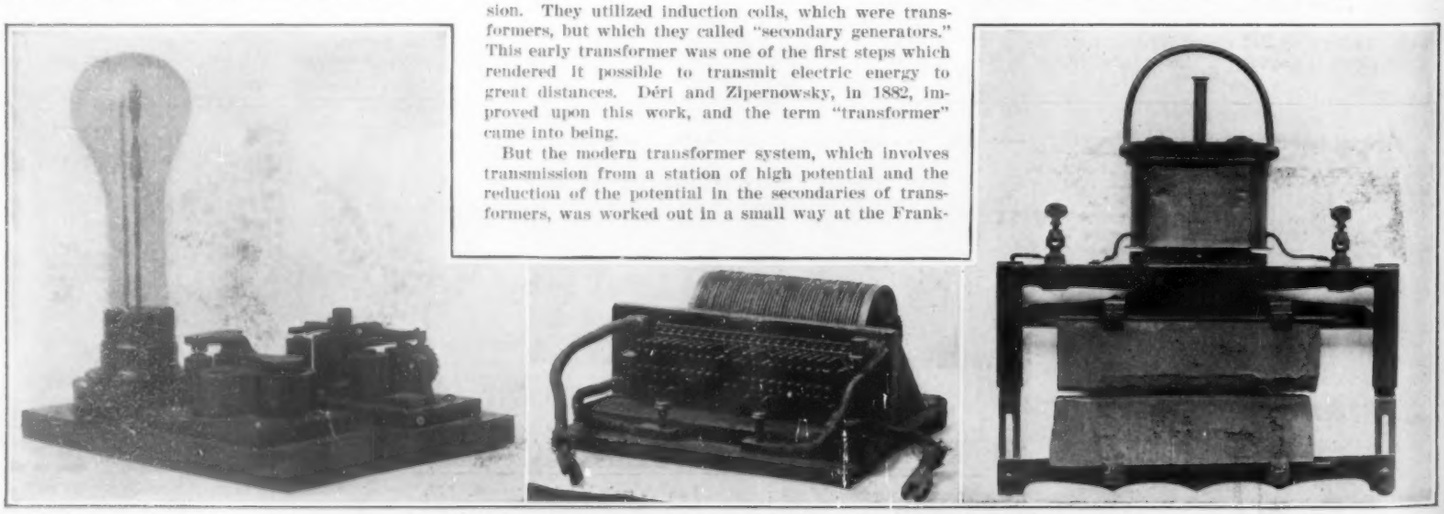
The storage battery, which plays an important rôle in power generation, began to assume practical form in 1882 when Camille Faure improved Planté's accumulator by inventing the pasted type of storage battery. Planté formed his super-oxide of lead after charging; Faure used a compound of lead oxide and lead superoxide, which he applied directly to the negative electrode.

The first alternating current central station of London was built by S. Z. de Ferranti somewhat later, and it served as a model for subsequent installations. In 1887 Nikola Tesla invented the polyphase alternating current motor which made it possible to transmit electrical energy still more economically. The first alternating current machine for generating polyphase current seems to have been built in 1888 by Hasselwander. In the same year Chas. S. Bradley patented a two-phase motor. The first installation for transmitting multi-phase alternating current at high tension was built in 1891 by von Dolivo-Dobrowolski of Berlin, between Lauffen and Frankfurt.

Refinement after refinement followed from that day to this. The introduction of the steam turbine caused the building of still larger generators than were used with the greatest of reciprocating engines. The demand for cheap electric power caused the harnessing of mountain streams and the transmission of the power many hundred miles to the consumers in the distant cities. The nickel-iron storage battery came into use, being invented by the Swedish engineer, Jungner, but perfected and placed on the market by Edison.

The Rise of the Electric Motor

Peculiarly enough, the motor antedates the generator. Indeed, any of the electro-magnetic motors in which the current was reversed would have generated a current so strong, if they had been rotated backward, that its presence could not have escaped notice. Yet hundreds of these machines were experimented with for

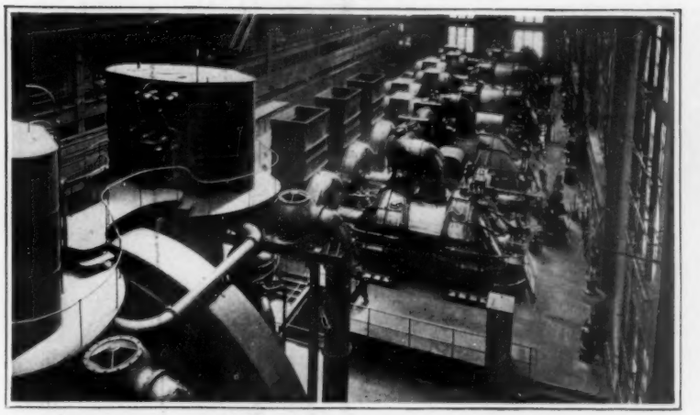


Left: Carbon arc type of electric lamp patented by Hiram Maxim on September 24th, 1878. *Center:* Original electric welding transformer invented by Elihu Thomson and extensively used as early as 1886. *Right:* Arc lamp invented by Wm. Wallace of Ansonia, Conn. The peculiar feature of this lamp was the use of the carbon plates 10 inches wide, between which played the arc

Milestones in the development of the electric lamp and the process of electric welding

more than a quarter of a century and the fact was never discovered, although all the while there was urgent need for some cheaper form of current generator than the usual zinc-consuming battery.

The development of the electric motor has followed more or less closely that of the generator; to be sure, for all practical purposes the motor and the dynamo are almost identical in general design. With the improvement in the generation of current, the motor, too, was improved, and its mechanical capacity kept pace with the electrical output of the generator. It remained for the pioneers to develop suitable systems for the economical distribution of current before the motor became a universal source of power, such as it is today. Year after year we find the electric motor growing in importance until it seems that practically every piece of machinery in the shop, store, home and elsewhere is driven by electricity, providing there is a source of current within ready reach.



A modern power-house showing the former reciprocating engine in the foreground and the latest type of turbine units farther back

The most startling application of the electric motor was no doubt the electric railway, beginning with the experimental attempts of Davenport in 1837. The possibilities of the electric motor in this field were seriously considered long before the electric motor made headway in other directions. In 1851 the versatile and daring Moses G. Farmer of Newport made rather unsuccessful experiments with an electric railroad, in which the current, derived from a battery, was sent through the rails. In 1851 Thomas Hall of Boston succeeded in driving a vehicle with a magnetic machine supplied from a stationary battery—an early attempt at electric automobiling. In 1854 M. Davidson also made experiments with an electric automobile. Numerous inventors tried their hand at the electric railway, which seemed to be a most difficult problem to solve despite its apparent simplicity in the light of present-day knowledge and equipment.

In 1879 Siemens constructed an experimental electric railway which actually carried passengers. Several others worked in this field in the following years, including Edison, who constructed a full-sized electric railway at Menlo Park during 1880-82. However, it was not until 1888 that complete success on a commercial scale was attained. The equipment of all the street railways of Richmond in that year, and the complete success of the installation, was the real beginning of the introduction of electricity for the operation of railways. As in the case of the dynamo and the motor, one refinement has followed another in the development of the electric railway and the electrified railway. As recently as 1901 Frank J. Sprague, the well-known American electrical engineer, invented his famous multiple unit system of control for electric railways, which has made possible the operation of electric trains in our subways and on our elevated railroads. In 1902 B. G. Lamme of the Westinghouse organization brought out the high tension motor for single phase alternating current, which was soon introduced on electric railways. And with a few more additions this brings us to the present electric railways which make their way through our city streets and spread far out in the country so as to weave suburbs and hamlets and cities into one, and to the present electrified railways which have banished the snorting, smoking and noisy steam locomotive.

How Electric Lighting Came About

Again we must mention that enterprising person, Moses G. Farmer of Newport, who in 1859 illuminated his house with forty-two platinum incandescent lamps, thus giving us one of the earliest instances of electric lighting. But it was many years before electric illumination was systematically developed.

The arc lamp and the incandescent lamp bore more points in common in the early days than they do now. For example, the first arc lamp to be extensively commercialized was the "candle" of Jablochkoff in 1876, which gave less light than many of the modern incandescents do, and embodied a "filament" at the top, the fusion of which started the arc. On the other hand, among the earliest incandescent lamps were the so-called "incandescence-arc" lamps, based on the principle of an arc playing between two incandescent wires in a partially evacuated bulb. Again, the material in both cases was the same, carbon being used for lamp filaments and arc electrodes. Subsequent development soon caused the two forms of electric illumination to drift further and further apart, as the arc lamp continued to use carbon and metallic electrodes and the incandescent lamp turned to osmium, tantalum and tungsten.

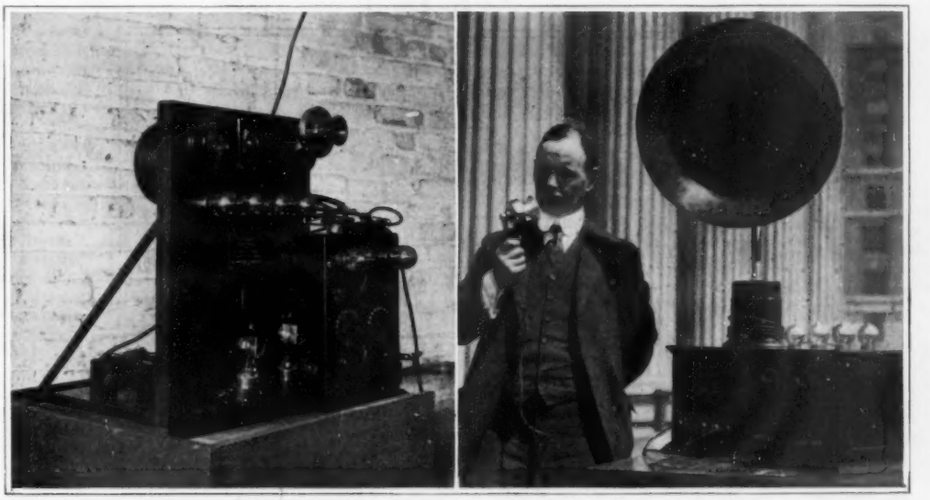
The arc lamp is a device of long standing in the art. Indeed, Sir Humphry Davy in 1801 first observed and studied the phenomenon of the electric arc. It was not publicly exhibited until 1809, when Davy, in the absence of a generator—he was too far ahead of electrical developments—made use of a mammoth battery of 2,000 primary cells at the Royal Institution, London, for his current.

We now skip several decades, during which the idea of electric illumination received much attention by experimenters and scientists, both in the form of crude attempts and in simple suggestions. Some of the suggestions and actual lamps are interesting and ingenious, but of little if any importance as far as the advancement of the illuminating art is concerned.

In 1875 the Sprengel vacuum pump, which became almost immediately an important factor in solving the problem of successful incandescent lamp manufacture, was introduced. The following year Lieut. Jablochkoff patented his famous "candle," consisting essentially of two vertical strips of carbon separated by a thin fusible insulating barrier, across the top of which an electric arc played. Europe proved quite a good market for this odd "candle," but it met with little success in the United States, where it came in direct competition with the early incandescent lamps.

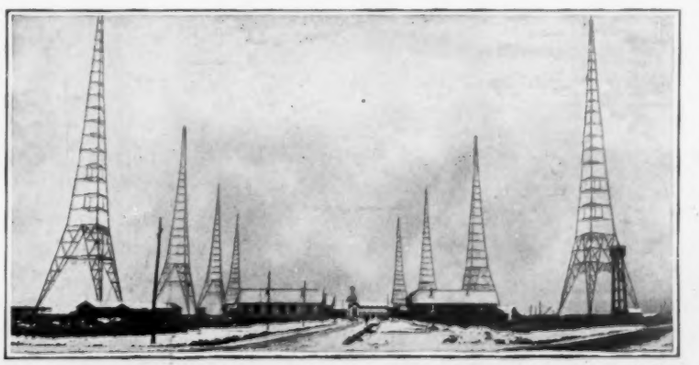
Meanwhile Charles F. Brush and Thomas A. Edison applied themselves to the stupendous and hitherto unsolved problem of utilizing electricity for general illuminating purposes. Brush exhibited his first arc lamp of the wonderfully simple and successful ring-clutch type in 1877, and in the next year introduced that other indispensable feature of his system, the series arc dynamo, and started arc lighting campaigns all over the world.

The history of the arc seems incomplete without mentioning the early work of Elihu Thomson. He invented a generator, absolutely unique. In connection with it he developed the magnetic blowout, which has been extensively employed ever since in controllers, lightning arresters, and circuit breakers. Indeed, the Thomson-Houston and Brush arc systems were active competitors.



Right: One of the many uses to which the vacuum tube has been put is the loud-speaking telephone. This apparatus enables a speaker to address tens of thousands of persons without raising his voice. He speaks into a mouthpiece and a bank of vacuum tube amplifiers magnify his voice many thousands of times until it thunders out of the huge horn. *Left:* A typical wireless telephone transmitter which can be attached to any standard light socket and operated on either direct or alternating current. Vacuum tubes play the leading role in this, as well as in all small and medium sized radio telephone transmitters

Two uses for the versatile vacuum tube of today



The Lafayette radio station at Bordeaux, France, which has a transmitting range of 12,500 miles—virtually half way 'round the world

The Great Search for Filament Material

In 1879 several inventors were working on the incandescent lamp problem, among them Sawyer and Man, who experimented extensively with filaments of carbonized paper; Lane-Fox, who used vegetable fibers; Swan, who publicly exhibited a lamp with a filament of parchmentized thread; Weston, who worked even at that early date with squirted and cut nitrocellulose, and Edison, who tried out substances far too numerous to mention here, but including platinum, lamp-black, tar, and paper. There were numerous failures among those working on the incandescent lamp problem, but these did not deter other inventors and experimenters from going ahead with what seemed such a futile search for a suitable filament material.

Edison's famous exhibition of his complete incandescent lighting system, when

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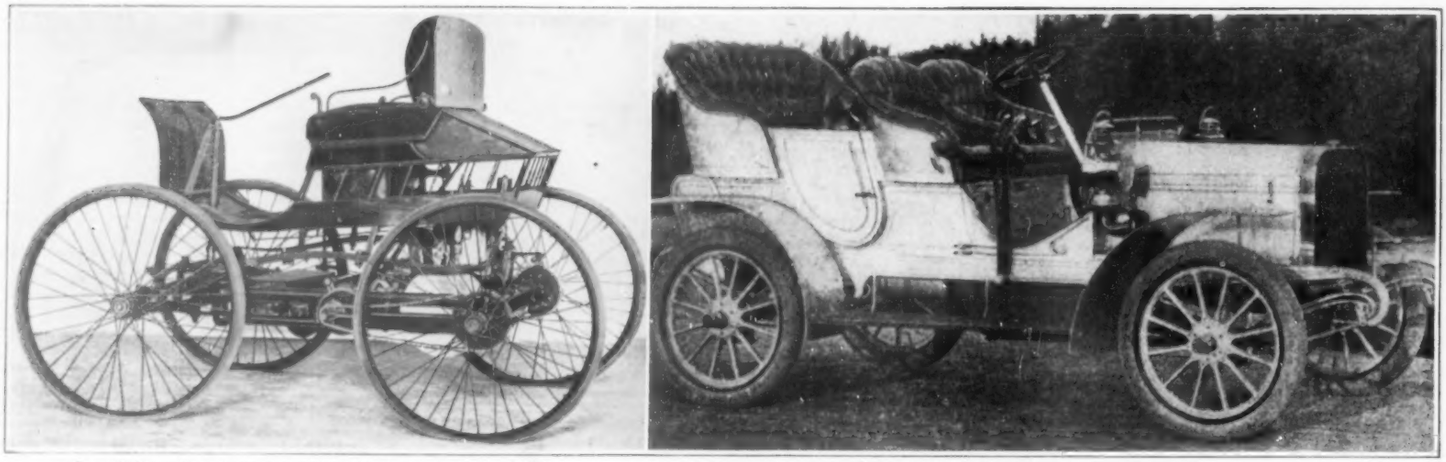


One of the earliest American models, the Duryea machine of 1894

The Winton of 1905, a typical machine of the period

Representative designs from the age of the horseless carriage and from the transitional period in which automobile design was crystallizing into its present form

The Rise of the Automobile

How One of the Props of Modern Existence Came Into Being and Acquired Its Present Position

THE first successful four-cycle gas-engine was built in 1876. The first successful application of such an engine on a vehicle took place in 1887. The manufacture of horseless carriages for sale was first undertaken in America in 1894. The industry was first recognized in the census reports of 1899, with an output of 3,700 cars. The truck was first differentiated from the passenger car in 1904. The million mark in annual production was first passed in 1916. Today there are seven million in operation in the United States. The automobile has been developed from its inventive origin in less than fifty years. Its manufacture has been developed from nothing in less than twenty-five years. In this time it has come to be the most vital single adjunct of modern civilization. Truly we are living in a rapid era.—THE EDITOR.

VEHICLES to propel themselves were designed long before the day of the internal-combustion engine. But the very name of road engine given to these as a class emphasizes their utter lack of true historical connection with the automobile of the present day; they represent merely isolated individual effort and are of antiquarian rather than historical interest. At the same time, we have automobiles on our roads today that run on other principles than that of the gas engine, and their proponents look more or less confidently toward their ultimate domination of the field.

But the purpose of this issue is to tell, not of all that has been or may be, but rather to show how the big things of today that did not exist 75 years ago have come into being. It seems therefore desirable to recognize that when we say "automobile" we mean the gas-driven car that dominates the field today; and, excluding the abandoned ideas of yesterday and the potentialities of tomorrow, to tell the straight story of how the machine was created that depends for its operation upon the explosion of a charge of gas within its vitals.

This story necessarily begins with the engine. The road locomotives of the decades before the 80's were so cumbersome and so generally objectionable as to make it clear in the retrospect that automotive progress waited on some new departure in the way of prime mover. With the ordinary cannon and rifle before him, the imaginative inventor of many generations realized that here was a means of power that wanted only proper control. As early as 1794 the British patent records give testimony of this realization; but the first essential of compressing the charge before firing was missing. William Barnett, in 1838, first grasped the necessity of compression; he was likewise the first to effect a moderately sensible solution of the ignition problem, designing a plug-cock that transferred a flame from outside the cylinder to inside at the critical moment, in spite of the apparently insuperable obstacle that the internal pressure was greater than the external.

The first man to attempt the explosion of the charge by means of the electric spark was E. Lenoir, in 1860; but while he manufactured several hundred engines, the ignition was not reliable. Neither did he have the proper conception of how to handle his explosive mixture. Clear ideas on this subject were first promulgated in 1862 by A. Beau de Rochas, who published a little pamphlet in which he defined clearly the intake, compression, power and exhaust strokes, and showed plainly why the cycle of these four operation was essential to the development of the internal combustion engine.

Otto's Engine and What Came of It

The Frenchman's work was lost sight of, however, and his four-stroke cycle had to be invented independently by N. A. Otto, who embodied it on his engine of 1876. This is so distinctly the parent of the modern internal-combustion engine that Otto is recognized as the inventor of this device. But his engine was sufficiently crude, in comparison with those of today.

In the first place, it was of a single cylinder, necessitating a fly-wheel of disproportionate bulk to carry the piston over the three unproductive strokes. The explosive medium was a mixture of gas and air, effected as today, before introduction into the cylinder; it was fired by means of a metal tube heated to incandescence. This tube led into the cylinder, through a valve which opened at the proper moment. The gas flowed into the tube, ignited, and communicated the state of explosion to the main body in the cylinder. The ignition valve closed at the completion of the exhaust stroke; like intake and exhaust valves, it was operated mechanically, but by gears rather than the cams of today.

There remained much to do to the Otto engine before it could be put on an automotive vehicle. It was a heavy, slow-running affair, making from 150 to 250 revolutions per minute. The engineers of the day believed that any greater engine speed was incompatible with durability and smooth running. Gottlieb Daimler showed the error of this by producing, between 1883 and 1887, small light engines running at about 800 revolutions. Another fundamental innovation, which, while not original with Daimler was first a complete success with him, was the use of a liquid fuel. This, of course, necessitated something in the way of a carburetor to impregnate the air passing to the cylinders with the vapor from the fuel. Preceding efforts in this direction were based on a faulty principle, relying on the air to pick up enough vapor while passing over or bubbling through the liquid. Under such treatment, however, the heavier fractions do not get taken up; the liquid in the mixing chamber gets heavier and heavier, until finally it comprises nothing that the passing air can take into suspension.

Daimler invented a device which, while lacking proper response to changed speeds and loads, in its essential features anticipated the modern float-and-jet carburetor. In his light, fast engine with higher compression than before, and his easily handled liquid fuel, he had the main ideas necessary to the installation of a gasoline engine on a vehicle. He actually equipped bicycles and carriages with his engines; and on March 4th, 1887, he operated the first gasoline-propelled motor car. He well deserved this distinction, for more than any other one man he invented the automobile.

Barney Oldfield and Henry Ford in the first car that ever traveled a mile a minute

Touching Off the Charge

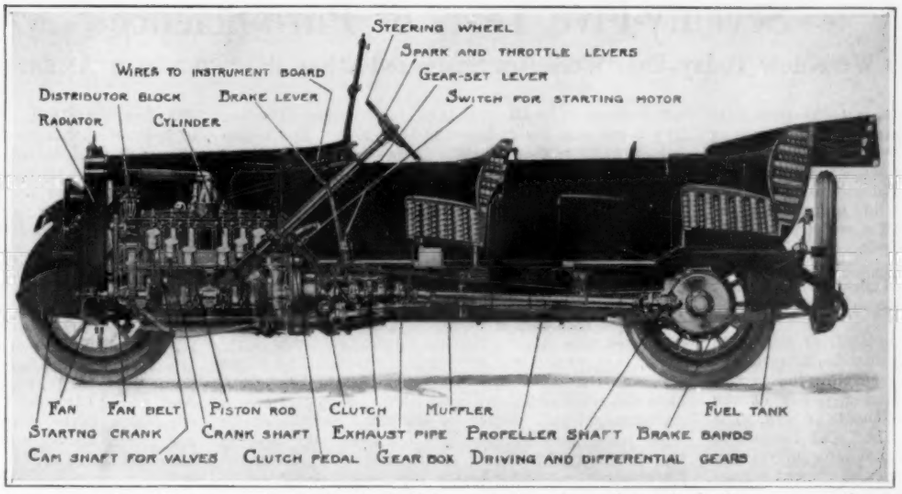
Daimler employed Otto's hot-tube ignition; but before he had it in successful operation on the road, an electric ignition device had been invented by Karl Benz. Benz fitted his engine to a tricycle, and though not exhibited until 1888, it was completely designed as early as 1885. He employed a battery for his current. But in spite of his example, the far less elegant hot-tube ignition persisted in favor among European designers, and it required fresh onslaughts from America, in the shape of the Haynes, Duryea, Olds and other models of the early 90's, to drive it from the field. Even then it hung on, with some of the European makers, until 1900 or thereabouts.

Electric ignition itself presents alternatives between dry battery, wet battery and generator as the source of current;

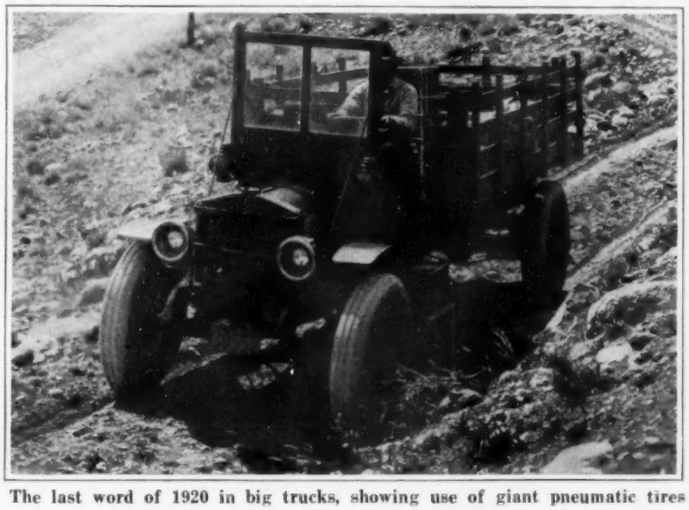
and between low tension with make-and-break gap, and high tension with fixed gap and jump spark. Each of the early designers worked out his own salvation in this complex business, and it is profitable to mention no names until we come to the inventions of Simms and Bosch that made the magneto the specialized and satisfactory machine that it is. The tendency at first, in turning from the hot tube, was toward dry battery and make-and-break spark; the refinements that make a magneto of the generator were not at hand, and there was hesitation about putting a wet battery on a moving vehicle. The late 90's saw the beginnings of the high-tension development which in the new century was to lead to the magneto, and at the same time found experimenters more willing to give the wet battery a chance. It was not until 1904 or 1905 that the magneto was strictly a high-tension device; and though it was gaining fast, at this date the battery, usually wet, was in the majority. When the Locomobile first appeared as a gas car, in 1903, it was far in advance of its time in carrying two wet batteries for ignition, with a dynamo for keeping them charged. Another look ahead characterized the Peerless of 1907, the first instance which the present writer has found of dual ignition with battery and magneto. On the whole, the tendency until 1910 or 1912 was distinctly away from the battery; and the magneto would doubtless have become universal, had not ignition got snarled up with another question which will be discussed presently.

The transmission of power from the gas engine is a problem wholly peculiar to that engine. For the gas engine will not start without external action; it will not start at all under load; and whatever load it is to carry must be picked up gradually. At the same time, satisfactory regulation of running speeds cannot be got solely by governing the engine, which is fundamentally a constant-speed machine; and the engine will not run backwards, so that reversing must be accomplished, if at all, by means of an extra unit in the gear assembly.

Here we have to introduce another name, with the statement that if Daimler was father of the automobile, Levassor was at least a foster-parent. This French pioneer acquired the French patents of Daimler, with the single purpose of applying them to an automotive carriage. He devised practically out of whole cloth the combination of clutch, gear-box and transmission which has stood ever since as a standard feature of automobile practice, its general features unaltered in the face of multitudinous changes in detail. At the same time he is the responsible author of the convention that puts the engine in front, with its crank-shaft parallel to the long axis of the vehicle.



A representative 1920 car of the high-priced, high-powered variety, shown in broken-away section to exhibit some of the parts which are to be recognized as characterizing the automobile of today, as distinguished from its predecessors of the horseless carriage and the transition periods



The last word of 1920 in big trucks, showing use of giant pneumatic tires

The Engine and the Car

We would not be understood, in thus evaluating the contribution of Levassor, as minimizing the ingenious devices which others since his time have added to make the operation and especially the control of the transmission simpler and more effective. The Levassor system, as crystallized by Panhard, called for a separate lever for each speed, or at best for a gear-box permitting passage from a given speed only to the one next above or below. The Packard design of 1902 marked an epoch, introducing the selective gear-set and the single lever in the H-slot operating all gears. During the ensuing eight or ten years the sliding-gear system with four or three speeds and reverse, controlled by gear lever and clutch pedal, together with the equally standard planetary two-speed-and-reverse two-pedal-control system, were developed to their present final form. But it was not until about 1910 that the left-hand drive first assumed a dominant position, so that the rather crude expedient of placing the control levers outside the car in order to have them at the driver's right might be eliminated, at least as a characteristic of American cars.

Otto's original engine was of a single cylinder, as was Daimler's and apparently all the others of the period. But the single cylinder with the four-stroke cycle means that the crank-shaft must revolve twice for each power stroke. An effort to avoid this by means of a two-stroke cycle appeared for a time destined to succeed. At least one of the American pioneers—Elwood Haynes—started with it; but largely by sheer accident, it was shelved in favor of the four-stroke cycle with multiplication of cylinders, which became universal. It was not at first apparent that this would go beyond the point of two cylinders, or at the very most four. In 1902, for instance, the Packard and the Knox were

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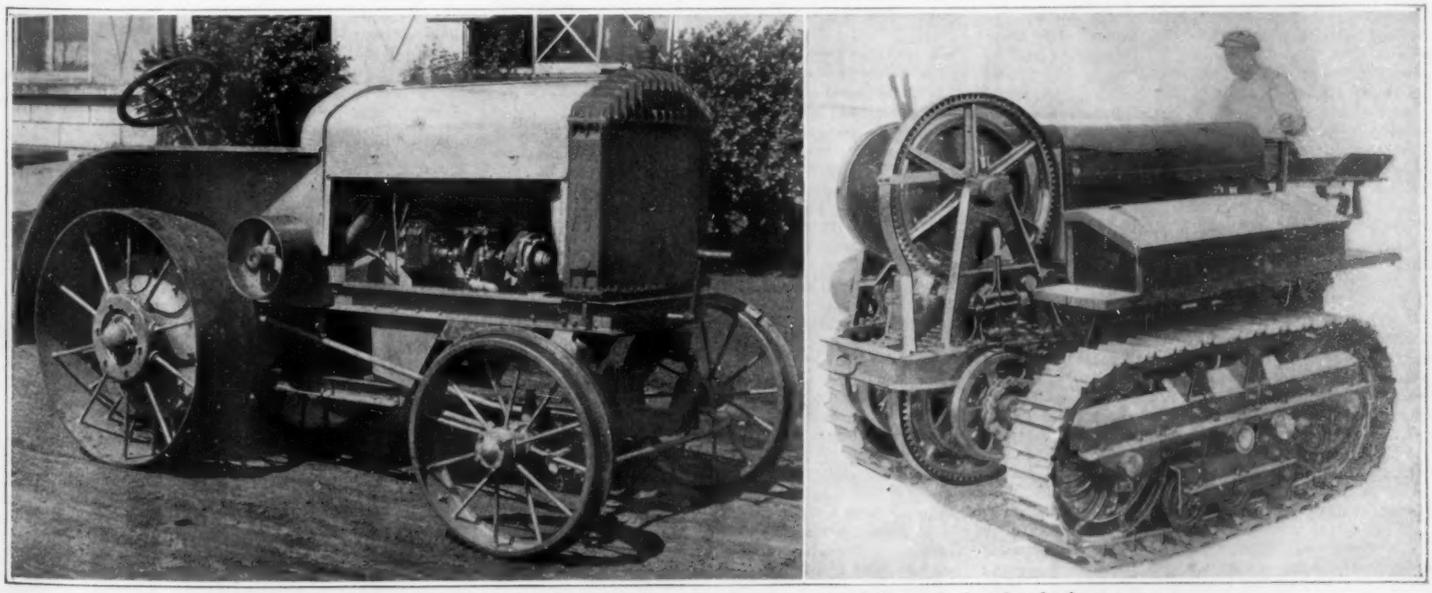


Typical tractors of the wheeled and track-laying species now employed for agricultural and other purposes

Seventy-Five Years of Pure Science

Some of the Things We Know Today That Were Not Suspected When the SCIENTIFIC AMERICAN Was an Infant

IF we compare the state of science today with that which existed in 1845, the first thing that comes to our attention must be the utter poverty of equipment of the former date as compared with the latter. In good truth the scientist of today ought to get results that were far beyond the reach of his grandfather, for he has tools of a character and of a sensitivity which his grandfather could never have pictured in his wildest dreams. It would be quite out of the question to catalog these; but we may at least mention a very few of the ones whose contribution to scientific advancement has been the greatest.

The microscope and telescope existed, of course, in 1845; but subsequent developments in the direction of improving the definition of the image in the former and of increasing the light-gathering power of the latter have almost made new instruments of both. The spectroscope, developed by Kirschhoff and Bunsen in 1859 along lines suggested by Fraunhofer fifty years earlier, is something at which even the present sophisticated age may well gaze in astonishment. That the light impulses sent out by different substances should be of different wave-lengths seems reasonable enough, and we know that if they are of different wave-lengths they must be of different colors. That the temperature and the pressure at the light source should make some difference in the impulses propagated seems equally reasonable; that a relative motion between source and receiving point should alter the apparent character of the received impulses likewise seems within the bounds of probability. But that a single small instrument of simple outlines should be set up which shall so analyze the light thrown into it that a mere scaling off of linear measurements shall at once give full information on all these points, and do this equally well whether the source of the light is at a distance measured in centimeters or in light-years—this really would seem, in the absence of performance, to push credulity too far.

Then, too, the physicist of 75 years ago had to depend upon microscopic scaling off, with all its inevitable errors, to give him minute measurements of dimensions. Today, through the work of Michelson based on the researches of Young of a century ago, we are able to use the wave-length of light as a measuring unit, and by the elegant method of interference fringes force millionths of an inch to stand out, clearly visible to the naked eye. This is a tool of which Michelson's predecessors could have had little or no inkling.

The Permanent Observation

Another vast advantage of the present-day investigator in any field is that he does not have to make his observations hastily, while the observed phenomenon is occurring, depending for subsequent use upon such of these observations as he is able to remember or to jot down in the few seconds available for this. Automatic and permanent recording, not merely of the investigator's impressions, but of all the facts in the case, is always possible. If it is a matter of telescopic or microscopic or unadorned visual observation, the camera makes the permanent record, or if necessary, the motion picture machine is called in. If it is a matter of sound, the phonograph is at hand. If it is almost anything else in the world, means are always at hand for forcing the phenomenon under observation to impress its peculiar features on an electric current, which in turn records them in the shape of a jiggly line traced on a revolving drum, or in some other way that makes them equally permanent. Then in every case the investigator is able to survey his results carefully and slowly and as often as he pleases, under the most favorable physical and mental conditions, free from all rush and all fatigue; to place the results of many trials beside one another and compare them directly instead of through mere memory; to apply the most excruciating care to the measurements that are necessary to quantitative determination; to refer again and again to the precise records and reproductions of his experimental results during the hard process of drawing general conclusions from these.

In enthusing over the major items, we should not lose sight of the very great importance of the relatively smaller developments. A little thing like the selenium cell, with its ability to translate light into an electric current and reverse the process to get back the original impression in all its details, is of no end of value. The X-ray and the radioactive body are of less consequence as tools than as contributors to new theory on the nature of things; yet their rôle as tools is by no means an insignificant one. The man who constructs a little exploring coil which, by revealing the magnetic structure of a metal part, makes it possible to give that part a searching physical test without the destruction of the tested piece that always follows the older and cruder method of finding the breaking point by breaking, has given science a new tool of great power. The pyrometer furnishes a means of measuring high temperatures, the electric furnace a means of producing them, that were quite beyond the science of 75 years ago. At the other end of the temperature scale we have the work of Dewar, who shows us how to create an unprecedented degree of cold and how to study what takes place at these low temperatures. And so it goes; every branch of science has made enormous instrumental advances in the past seven decades.

IT is a very large order to attempt the characterization of the entire scientific achievement of seventy-five years; it is obviously impossible save where the developments of the period considered show sufficient unity to make it possible. To an extraordinary degree the seventy-five years of the SCIENTIFIC AMERICAN'S *life show this unity; and the word that describes their trend is* GENERALIZATION. *The whole tendency in every field of science has been to include more and more apparently isolated phenomena under a single broad statement, and to show that the things in this universe that are really unrelated are amazingly fewer. And no demonstrable end to this is even yet in sight!*—THE EDITOR.

Laying the Foundations of Modern Physics

It is largely as a result of all this marvelous equipment developed since 1845 that one may survey the whole field of science and find hardly a single part of that field which has not been completely dug up and planted afresh in matters of fundamental theory during these 75 years. In the forties, for instance, the science of physics in so far as its elementary concepts are concerned was in a state of confusion. Mayer and Joule had just given to the world their determinations of the mechanical equivalent of heat, thus laying the cornerstone for the entire structure of the modern physics. It is difficult to conceive how physicists before 1842 made any progress at all, in ignorance of the relation between work done or energy employed, and heat produced. But even for many years after 1842, in one fundamental point there existed hopeless confusion, on account of the want of an adequate distinction between force and energy. Physicists had gradually acquired the doctrine of the indestructibility of energy; but this was expressed in terms of the so-called law of the conservation of force. Promulgated as one of the triumphs of science, this supposed law was far from satisfactory. The troubles of scientists in trying to reconcile this pronouncement with the facts, their comments and explanations in this connection, make curious reading today when we know that force can be created and annihilated at will, when we have learned to distinguish definitely between force and energy. But after years of work the distinction was formulated and a threefold system of units established for physics, the members being force, work and energy. These were definitely distinguished each from the others; and at once the great doctrine of the conservation of energy, unproved though it be, obtained universal acceptance by men of science and today is universally used as a working hypothesis, with proper modifications in the light of the latest developments.

It is impossible to dwell too strongly on this major achievement of the physics of the fifty years from the forties to the nineties. Until force was adequately distinguished from energy the doctrine of the conservation of energy could not be used, and it is precisely on this doctrine that the whole of the modern physics is constructed. It would be fair to term the theory the greatest discovery of the century in physics, and to name Lord Kelvin, the man who had most to do with its precise formulation and general acceptance, as the foremost physicist of the century—or at least the one who has left the deepest imprint on his science.

This, however, is but one thing that has happened to the physics of 1845. At that date the work of Young and Fresnel was sufficiently old to make the wave theory of light universally understood and universally accepted. And since the doctrine that light is a wave motion called for a medium for the waves, the luminiferous ether had been invented—invented seems really the word, since direct experimental evidence of the ether's presence was lacking from the beginning and has remained lacking. It remained for the decade of the fifties to put to the fullest use this perfectly continuous and perfectly incompressible and perfectly rigid and perfectly elastic medium which the physicist had postulated, by making it carry the electric current as well, in the shape of the waves which Clerk Maxwell indicated as the basis of this current. And where Clerk Maxwell had suggested the obvious conclusion to be drawn from this that light waves and electro-magnetic waves and presumably other yet-to-be-discovered waves were fundamentally the same, differing only in wave-length, it remained for Hertz to prove this, and to give real form to the very elegant conception of a long series of waves, substantially identical in nature, running from electric impulses hundreds of yards long, down through the shorter and shorter waves of wired circuits, of radiant heat, of visible light, and finally of the invisible ultraviolet portion of the spectrum that carries the wave-length far below the fifty-thousandth part of the inch. This generalization of many apparently diverse phenomena under a single caption, despite the atrocities that have been committed in its name by those who failed to understand its proper limitations, was a tremendous step in advance, and one thoroughly characteristic of the period in which it occurred.

The twenty-five years since the appearance of our fiftieth anniversary number have been almost as sharply marked off in the history of physical science as they have by the golden and the diamond jubilees of the SCIENTIFIC AMERICAN. For where the fifty years had been devoted to a laborious building up of the two generalizations outlined above, the twenty-five might well appear, to one not thoroughly alive to the full significance of what was being done, to be given over to efforts to tear down these generalizations. The older members of our staff remember well the opening gun of this campaign; in December, 1895, they participated in an informal editorial conference, at which the question was discussed whether to accept or to reject the wild yarn that had come over the cable from Germany to the effect that Professor Roentgen had discovered a new kind of light to which many substances ordinarily opaque were more or less transparent. When fuller details had come through, and the scientific world was able to assure itself that this extraordinary result was a fact, the tendency was generally to assign the X-rays a place in the table of wave-lengths, putting them at the extreme point of the short-wave-length end. But they were troublesome creatures; they seemed at the same time to be waves and not to be waves—to be at once electrical and material in nature. And here the physicist would have been held in suspense for a long time, had not the chemist been unexpectedly precipitated into the problem with him.

Ordering the Elements

The decade of the 40's had found the chemist just come into undisputed possession of two tools of the greatest importance—the concepts of the atom and of the molecule. The very clear notions of how and why compounds are formed which resulted from these ideas, and from the knowledge of valency developed during the 50's, led to a precision in analysis and in terminology that had always been lacking. It led at the same time to clearer ideas on what constituted an element, and to the discovery through analysis of a number of new elements, extending the list of these to something like seventy. It made it possible both to distinguish with certainty between atomic and molecular weights, and to determine the former with greater precision than ever before.

As a direct consequence of all this Newlands in England, Hinrichs in America, Meyer in Germany, and Mendeleef in Russia had their attention called to a mathematical relationship which, though rough, seemed clearly to exist between the atomic weights.

Mendeleef was most successful in working out this relationship, and in showing that when the elements were arranged in groups with attention to atomic weights, physical properties recurred in a most striking manner. It is his name that is associated with the periodic law which he formulated, and which constituted the first of the great chemical advances of the period we are discussing.

On the surface this looked more or less like a step backward, a return to the days of the man who insists that there must be only seven planets because seven is a perfect number, or that there ought to be some connection between the arrangement of the seeds in an apple and the vertices of that particular one of the regular polyhedrons which strikes the individual fancy as most beautiful. But while many chemists were inclined to dismiss it with a shrug as being of such caliber, it did not warrant this summary treatment. It can be accepted as entirely rational that there should be such a connection as Mendeleef discovered running through the atomic weights and the properties of the elements—if only we are willing to interpret this state of affairs as indicating that the elements "are not separate bodies created without reference to one another, but that they have been originally fashioned, or have been built up, from one another [or from some common infra-elementary material] in accordance with some general plan." This was the big idea behind the periodic system, and this was the idea which the chemistry of the latter half of the nineteenth century, following that system, developed. It was an idea wholly foreign to the chemistry of 1845, and would have been regarded by preponderant opinion of that date as a survival of or a reversion to the concepts of alchemy. Its acceptance, with all the implications regarding the eventual possibilities of transmutation of some sort, is the logical outcome of the trend taken by experiment and discovery, and constitutes easily the major feature of 75 years of chemistry.

Matter and Electricity

The major feature, perhaps; but by no means the climax. This came in the chemical world, as in the physical, more or less as an electric shock; and this in spite of the fact that just as Crookes and others had shown results largely anticipating those of Roentgen, Becquerel and others had really paved the way for the Curies. The precise terms of the discovery of radium, again like that of Roentgen, were for some time in doubt; it was not immediately clear whether radium gave forth energy alone, or matter alone, or an ambiguous combination of the two; nor whether it did this with or without permanent loss to itself. Accordingly there was a great deal of concern lest the law of conservation of energy, and even that of conservation of matter, should be shown to fail. Eventually the new discovery was boiled down to rock-bottom facts, collated with the X-ray development, and used as the moving force in further investigations designed to clear up the obscure points; and chemists were then in a position to wrestle with it in the search for its true significance.

There is no space here for any account of this struggle, but the most probable conclusions that have been drawn out of it must be set down as the summation of the physical and chemical development of 75 years. For these conclusions bring together the suggestion forced upon the physicist that matter and electricity are in some way related, and that forced upon the chemist that all the elements are in some manner of the same stuff. Without troubling ourselves too much about exact definitions of "nucleus" and "electron," "electricity," and "matter," it appears that the atom is composed of a nucleus that is mainly matter and one or more electrons that are mainly electricity. Presumably the nucleus and the electrons are identical for all atoms of all elements. With perhaps a little less confidence we may say that presumably some further facts will come out that will show a further degree of identity between nucleus and electron, between matter and electricity. For the present, if we cannot say that matter is electricity, we may at least assert with confidence that the distinction between different forms of matter is wholly an electrical one. And the observed facts of radio-activity and its allied phenomena are very nicely explained by assuming that the electrons are able to detach themselves and travel about "on their own" with some freedom under appropriate conditions.

A further development in line with this has come, in the immediate present, from the field of pure mathematics. It is altogether too early to attempt to place the Einstein theories in their permanent place. It is not too early, however, to say that these theories indicate a unity between apparently diverse things such as had never before been suspected. It shocks our sensibilities to be told that energy and matter are identical to the extent that we may write an equation showing how many ergs it takes to equal one gram; and that time and space are identical to the extent that we may write another equation showing how many seconds are the equivalent of one centimeter. Nevertheless, this is in direct line with the whole tendency of nineteenth and early twentieth century science, which has moved always in the direction of generalization, always in the direction of revealing that things previously supposed to be different are in reality not so.

The pure science of today is the applied science of tomorrow; hence one is somewhat in doubt as to just what may properly be included under the title of this article. It seems fair enough to say that pure science is science for its own sake, the desire to know for the mere sake of knowing, without any question of possible applications to the affairs of ordinary life. In this sense electricity was once a pure science, but today it is anything but that—its every fact and principle are put to work smoothing the path of the human race. But there are still pure sciences, sciences that are pursued just for the sake of driving the facts to their ultimate refuge. Of course the astronomer's findings are put to daily use in the determination of time and direction, and the geologist's are applied in the search for oil deposits, and the biologist's in plant and animal breeding; but this is something that the astronomer and the geologist and the biologist cannot control. There should not be great difficulty in steering a straight course between the pure and the applied; and surely astronomy is the science which is pure to the last degree.

With Spectroscope and Camera

The astronomer of 1845 could turn his eyes on such a glorious past that he might have been pardoned for lack of confidence in his future. The century immediately behind him had been one of extraordinary achievement; but the invention of one instrument alone sufficed to enable the problematical future wholly to eclipse the past. The astronomer today turns his spectroscope upon a given star, and tells us precisely what chemical elements are present there, the approximate temperature and pressure under which they stand, whether the star itself is old or young as star-life goes, what stages it has been through and what it has yet to undergo, and how fast it is moving toward or away from us. On top of this he can usually manage a pretty shrewd guess as to how large and how bright it is and how far away from the earth. The astronomer of 1845, if asked for these data, would have protested that he could get them only by visiting the star in question. But today we bring the star into our laboratories here on earth, and achieve the same result that would be effected by going to the star. From an imaginative viewpoint, this might fairly rank as the most amazing thing in all science.

SPECTROSCOPE and camera are merely two of the most vitally important, the X-ray tube one of the most spectacular, of thousands of instruments, scientific and practical, which have been placed at the disposal of the scientist since 1845. It is with these instruments that he has been able to make the tremendous advances that this story endeavors to record in barest outline; and no survey of the period would be complete that did not place the utmost emphasis upon the fact that the past seventy-five years have been an era of extraordinary instrumental development.—THE EDITOR.

Hardly less important to the astronomer than the spectroscope is the procedure now opened to him of permanently recording—not merely the observations which he might have made, but billions upon billions of observations which, unaided by the camera, he would never have had time or ability to make. Tentative efforts in this direction were made by Arago, in France, and by the senior Draper, in America, in 1839, just before our 75 years commenced to run.

Real success waited until 1880, when the junior Draper in this country and Gill in South Africa made the first adequate telephotographs, taking as their subjects a nebula and a comet respectively. Today star plates by the thousands are in existence, covering all the heavens and all the time since the beginning of the process. No other method is seriously used for the exploration of the sky. For to the advantage, already discussed in connection with the general case, that it gives a permanent record, it adds a second, that this record can be as complete as desire and weather permit; and a third, that the camera is a better observer than the human eye. A single observer with an equipment of cameras is limited, in the amount of material which he can accumulate for future study, only by the number of telescopes available. And when we look through a telescope, with the trifling reservation that concentration of attention on a given part of the field may help a little, we see at once all that we are going to see; whereas the longer we follow a certain bit of sky with the camera, the more stars will, by the accumulated effect of the minute beams of light which they throw upon the plate, make an impression which shall rise above the threshold of microscopic visibility. When the astronomer examines, with a high-power microscope, a photographic exposure of several hours, he is going to see uncounted thousands of stars that no telescope will ever reveal to his eye. With this increased power of observation, and an automatic memory that extends back at least twenty years and is able to recall for him anything that he may wish to know about the appearance of any region of the skies at any date during that time—well, small wonder that he is able to extract from the stars secrets which must have seemed forever unattainable to the astronomer of 1845!

The Riddle of the Universe

The photographic camera and the spectroscope have worked together in new attacks upon that fundamental question of the universe—whence, when, how, came the stars and the planets? The mathematical physicist too brings new resources of calculation to bear upon the problem, and is able to tell us that Laplace's nebular hypothesis, which our grandfathers considered as absolute truth and the crowning achievement of their cosmic science, is simply foolish, in that incandescent gas never does and never can behave in anything like the manner which this hypothesis demands. With this means of confining himself to physical possibilities, the astronomer has now a fairly definite idea of the course of stellar evolution and decay, and will point to this and that nebula and star and star cluster as illustrations of the several stages. And where the astronomer of 75 years ago thought he was on the point of placing dimensions to the universe, there has been a curious double overturn of opinion. Bigger telescopes and the camera so extended the visible field that no more than ten years ago a competent writer very properly said that all previous inferences as to the limitations of the sidereal system had been discredited, and that in spite of the wonderful instrumental advances, knowledge of the exact form and extent of the universe seemed less attainable than in the first half of the nineteenth century. Today, however, there is good ground for the belief that a concerted attack on the problem, with every mathematical and instrumental resource employed to the full, has at length struck bottom, and that as a tentative estimate of the extent of starry space we may set down some such figure as 300,000 light-years—which sounds much more impressive, though at the same time more meaningless, if we translate it into 2,000,000,000,000,000,000 miles.

The astronomer has collaborated with the geologist in estimating the time necessary for the earth and the rest of the universe to have passed through the various stages of which legible records remain in the rocks and in the skies. It may be laid down as a general principle that each generation since 1845 has felt obliged to throw out of court, as hopelessly inadequate, the most liberal estimate that the preceding one felt justified in making. In 1845 there were plenty of people who did not feel it inconsistent with the scientific viewpoint to believe that the universe was about six thousand years old and to set a date for its creation little if any less absurdly definite than the celebrated statement of the satirist to the effect that it took place at 10 A. M. on Friday the 16th of March in the year 4004 B. C.

Today it is quite out of the question to lay down anything approaching a definite consensus of opinion as to the age of the universe; figures ranging from a hundred million to a billion years are laid down as the lower limit and there really does not seem to be much that can be said definitely on the subject, except that, subject to correction by Professor Einstein, eternity is a long, long time, and that the universe has doubtless used the best part of it in coming to its present condition.

The Mastery of the Skies

How the SCIENTIFIC AMERICAN Has Been Privileged to Chronicle the Development of Airship and Airplane

Lilienthal, the German experimenter who discovered the means of controlling the balance of flying machines, and one of his many gliders with which he made his gliding flights

THE Burton family, encircling the fireside, read with unconcealed wonder the account of a hollow globe of oiled-silk filled with hydrogen gas, thus giving it a sufficient buoyancy to travel through the air. And they marvelled still more at the spindle-shaped saloon, suspended beneath the balloon, carrying 5,000 pounds of passengers and luggage. Twenty-five passengers in a balloon traveling at 100 miles per hour!

What of it? Nothing alarming or startling, in view of our present-day achievements. But the foregoing-mentioned facts were being read in the SCIENTIFIC AMERICAN of September 18th, 1845. Visionary as such a scheme seemed at that time, the editors of this journal had the foresight and courage to give it the stamp of their approval. They held that the seemingly impossible thing could be done, given the proper time and development which must necessarily precede any epoch-making invention.

Were they correct? History speaks for itself. Seventy-five years later, or to be exact, shortly before the dawn of July 6th, 1919, the Editor-in-Chief of the SCIENTIFIC AMERICAN stood out on Roosevelt Field scanning the early morning horizon for the coming of the monster dirigible, which was to mark the completion of the first westward transatlantic flight. Later, as the huge British R-34 dirigible strained at the hundred cables which moored her to Long Island soil, the SCIENTIFIC AMERICAN might well boast of a vision come true. For the R-34 in 108 hours traveled 6,300 air miles from East Fortune, Scotland, to Mineola, Long Island, due to adverse winds. And on the passenger list were thirty officers and men, and a stowaway!

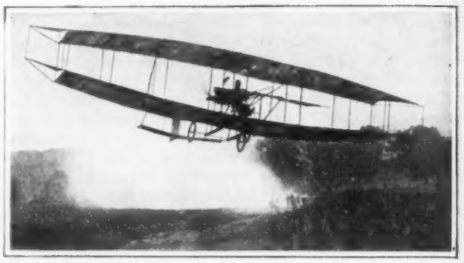
The Path of Least Resistance

Always has it been man's ambition to fly with wings, emulating the easy flight of the bird. But man soon learned to his sorrow that he had not the muscular power to flap a pair of wings of sufficient spread to carry him through the air. And in the absence of any other form of motive power, man naturally gave up the attempt for the time being.

The free balloon, invented in 1783 by the brothers Joseph and Etienne Montgolfier at Annonay, France, proved to be a simple way of overcoming the pull of gravity which holds us hard and fast to the ground. Immediately men in many countries took up the balloon as a thing for speculation and experimentation. The heated air of the Montgolfier balloon was soon replaced with hydrogen, thus marking a very material step forward in the art since this gas lifts about 68 pounds per 1,000 cubic feet as against some 10 pounds for the highest temperature that is practical for a hot-air balloon. The use of coal gas for inflation, first made by George Green, an English aeronaut, in 1821, constituted another important advance; for though coal gas lifts only about 35 pounds per 1,000 cubic feet, its production is very inexpensive and its use sufficiently satisfactory for sporting purposes and aerial exhibitions.

John Wise, America's pioneer balloonist, invented in 1844 the rip panel. This is a ribbon covering a vertical seam in the upper half of the balloon, which, on landing, can promptly be jerked off to allow instant deflation and thus prevent dragging by the wind. This last invention virtually closed the experimental era of the free balloon, for this has not undergone any notable change in construction during the last eighty years.

The modern free balloon has a bag made of rubberized fabric or varnished silk and is equipped with a wicker basket in which are carried various instruments for recording barometric pressure and altitude, a compass, maps and ballast. Its size varies from 9,000 cubic feet to 80,000 cubic feet; this is the average, for much larger balloons have been built and successfully operated, such as the German "Preussen" in which Prof. Berson and Dr. Suring rose in 1901 to the highest elevation ever reached by a balloon—34,430 feet, or nearly seven miles. This balloon had a capacity of 300,000 cubic feet. Again, the largest hot-air balloon ever built was "Le Flesselles," which was launched at Lyons, France, in 1784 and measured 100 feet in diameter and 130 feet in height. Its volume was 590,000 cubic feet.



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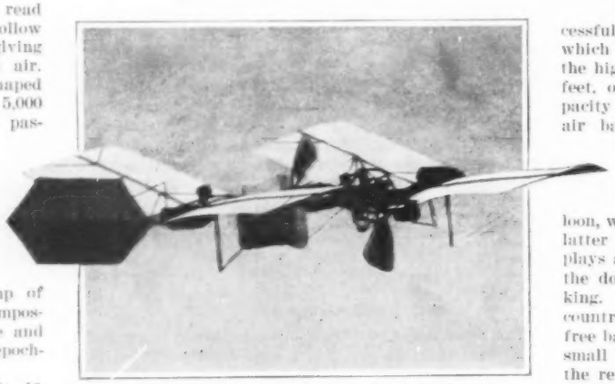
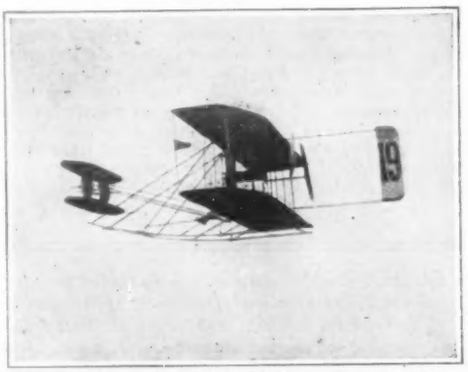
The "June Bug"—the first machine built under Curtiss's direction, which, on July 4th, 1908, won the Scientific American Trophy for first public flight of one kilometer



The man-lifting monoplane built by S. P. Langley, in 1903, and which, but for its defective launching device, would have flown under control



One of the early Wright biplanes flown in 1908, both here and abroad. This machine was launched by means of a catapult and rail arrangement

Despite the development of the dirigible balloon, which is a natural outcome of the free balloon, the latter has still a very definite field of usefulness. It plays a prominent part in the field of sport; indeed, in the domain of sport the free balloon has been called king. Annual competitions are held in the principal countries among the foremost balloonists. Again, the free balloon is used in scientific research, in which case small balloons equipped with scientific instruments of the recording variety are used to great advantage for investigating the constitution of the higher atmosphere. Some of the so-called sounding balloons have reached astounding altitudes; the world's record belongs since 1911 to an Italian sounding balloon which rose to an altitude of 114,900 feet.

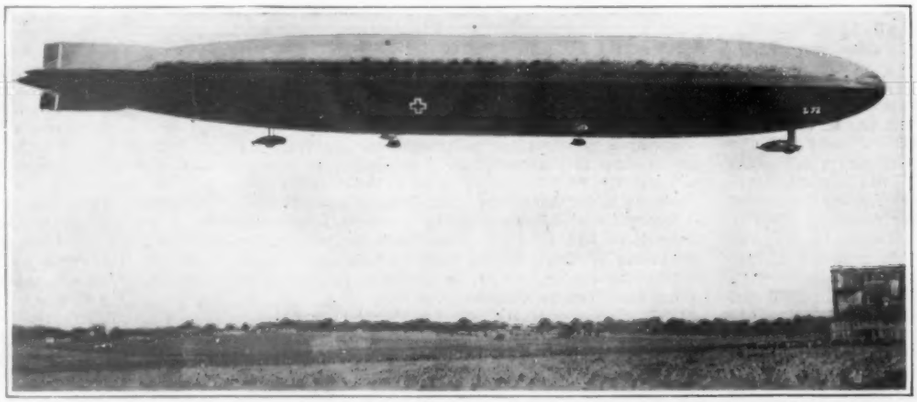
The Gas Bag and Modern Warfare

During the Civil war and particularly during the Franco-Prussian war the free balloon played an important part in the operations, thus establishing itself in the service of the soldiery for all time to come. The siege of Paris in 1870-71 brought forth the free balloon as a satisfactory means of transportation for passengers and dispatches over the German forces. By means of free balloons some 164 passengers were carried out of Paris, together with 3,000,000 dispatches. Out of 66 balloons, only five were captured by the Prussians laying siege to the city, and two were lost in the Atlantic. In fact, so great was the moral and material success of this enterprise that Bismarck threatened to shoot every aeronaut as a spy, and Krupp produced the first anti-aircraft gun.

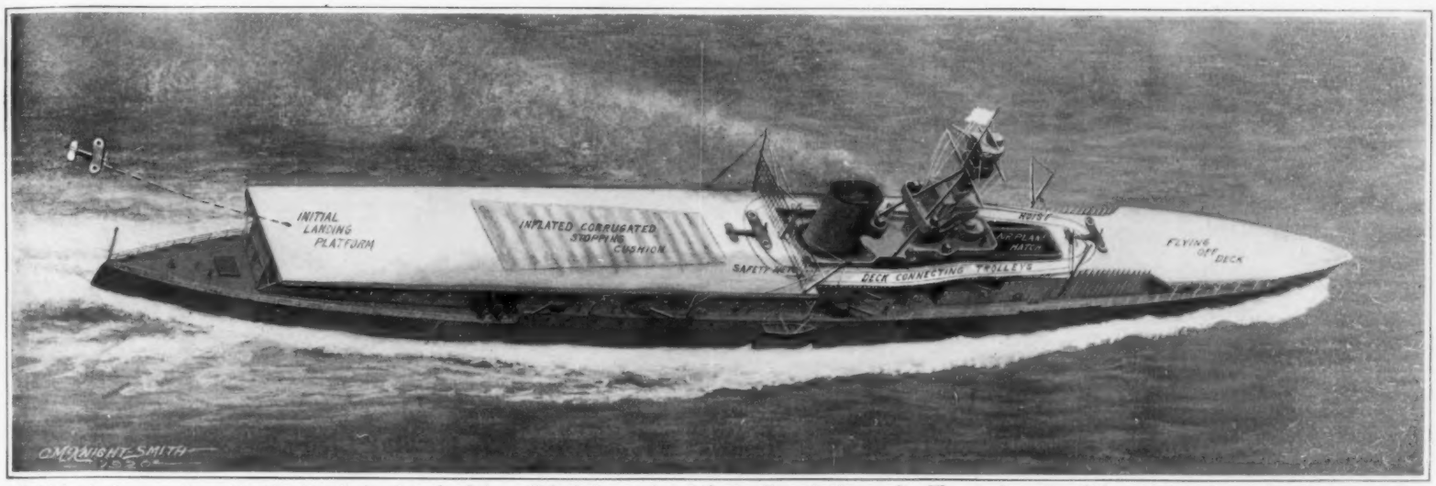
The wide sweep of the horizon which a balloon affords to its occupants marked this craft upon its very inception as an ideal instrument for military observation. But as the balloon always follows the direction of the prevailing wind it proved necessary to secure it to the ground. In this manner came about the captive balloon. Originally, this was nothing more than a spherical balloon which was attached to the ground by means of a cable.

For the Paris Exhibition of 1878, the Frenchman, Giffard, built a gigantic sight-seeing balloon. This craft, which had a volume of 882,500 cubic feet, carried thirty-eight passengers at a time to a height of 1,600 feet, and was hauled down by means of a 300-horse-power steam winch. This balloon has remained the largest spherical of either free or captive type.

The defects of the ordinary captive balloon were overcome by two German army officers, Captains Parseval and Sigsfeld, who



Zeppelin L-72, one of the present-day rigid dirigibles capable of crossing the Atlantic. This design, the outcome of the war, no doubt is the forerunner of the commercial dirigibles of the near future



British airplane mother ship "Furious," showing the flying-off deck forward and the landing platform aft. The airplane, it will be noted, lands on the platform, runs along onto inflated corrugated stopping cushion, and is brought to a dead stop by the safety nets. The airplanes are housed below

produced in 1893 the so-called kite balloon—a craft which has proved so successful that it is now recognized to be an indispensable observation agent of every up-to-date army and navy.

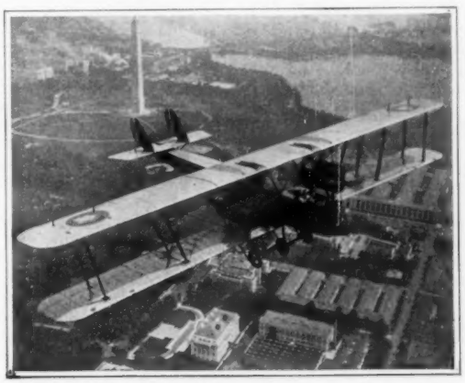
The kite balloon consists essentially of an elongated gas bag which is divided into two unequal portions, the larger of which (comprising about four-fifths the total volume) is filled with hydrogen, the remaining one-fifth constituting the ballonet, or air cell, and this is automatically inflated by the wind through a convenient aperture. The ballonet creates within the gas-bag an excess of pressure equal to the pressure of the wind plus the static pressure of the hydrogen, thus enabling the balloon to maintain its shape regardless of any wind the mooring cables can withstand. As air is heavier than hydrogen, the ballonet causes the balloon to assume an inclined position which enables it to counteract the depressing tendency of the wind. In order to keep the craft always head-on to the wind, a sausage-shaped pneumatic fin is fitted to the rear of the envelope, which is inflated the same way as the ballonet; longitudinal stability is further insured by lateral sails and a device similar to a kite's tail.

As a fire-control station for military and naval operations, the kite balloon far surpasses the airplane, for it affords a steady platform wherefrom field glasses or telescopes can be used to great advantage.

In the Great War the kite balloon was used on practically every front. On the Western front alone hundreds of them dotted the rears of the Allied and the German lines. Fortunately for the occupants of kite-balloons, who have no means of defending themselves against airplane attacks, suitable parachutes have been devised which permit them to jump out of the fired balloon and make their way to the ground in safety.

A great improvement was achieved in the performance of observation balloons in 1916, when Captain Caquot of the French Army, invented the kite-balloon bearing his name. This craft has a streamline shape and is fitted with three pneumatic fins at the rear, which do away with the cumbersome fittings of the German balloon. The Caquot balloon can stay aloft in much higher winds and possesses greater stability than the Parseval; its use proved such a success in the war that all the Allies adopted it and the Germans promptly copied it.

Put a power plant into a suitable free balloon and you have a dirigible. So it is quite obvious that the free balloon, sooner or later, gave birth to the dirigible of later-day aviation. And with the introduction of a power plant the balloon became a more positive means of transportation, since it no longer depended upon uncertain winds to take it in any direction they might elect.



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A present-day twin-engined biplane—the Martin Bomber—in flight over Washington, D. C.

Free Balloon + Power Plant = Dirigible

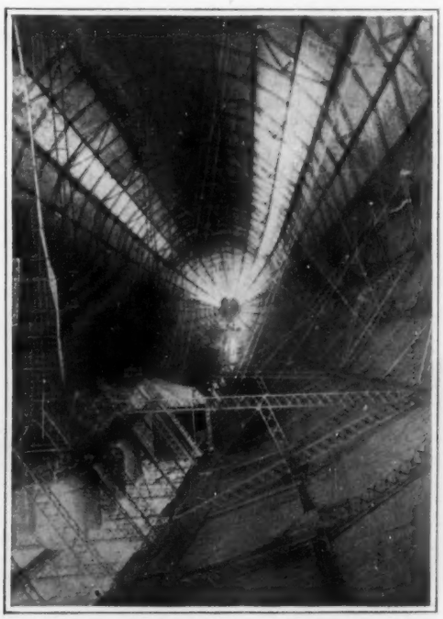
The basic elements of an airship are (1) an elongated gas-container, called *envelope*, streamline shaped in order to attain the greatest speed with the least expenditure of motive power and stability when under way; (2) one or more cars containing the power plant, the fuel supply, the crew and the passengers, as well as a commercial or military load; (3) a system of connection between cars and hull; (4) such means as will ensure the permanency of the hull's shape; and (5) such means of control as will effectually regulate the longitudinal and vertical equilibrium.

The dirigible more than any other modern machine represents the collaboration of almost countless inventors extending over several generations. Indeed, no one man can be accorded the credit for the dirigible. However, three men may rightly be considered as the founders of the science of airship construction. These were: General Meusnier, of the French Army, who in 1784 laid down the fundamental principles of the non-rigid airship; Colonel Renard, also of the French Army, who designed and built in 1884 the first airship that conclusively demonstrated its ability to navigate the air in any direction desired by the pilot; and Count Friedrich von Zeppelin, a German cavalry general, who devised in 1900 the rigid airship and brought it through persistent work to its present stage of development.

The space allotted to this broad subject of aviation does not permit us to enter into an exhaustive study of dirigible design and construction, but suffice it to say that there are two main classes of dirigibles, the rigid or structure airship, in which the permanency of the bag or hull is attained by means of a rigid framework covered with fabric which encloses a number of drum-shaped gas bags, and the semi-rigid airship in which the permanency of the hull is insured by maintaining within the flexible envelope a pressure superior to the atmospheric pressure.

(Continued on page 362)

In the chart room of the R-34 during the transatlantic journey from Scotland to Long Island



View inside the huge bag of the Zeppelin L-72, with the gas bags removed

Interior of one of the passenger-carrying airplanes now in regular use in France

Left: A corner of the Patent Office, showing how thousands upon thousands of documents are filed away for reference purposes. *Right:* An examiner's room in the Patent Office. It is interesting to note that in 1836 the Patent Office became an independent bureau, headed by a commissioner, assisted by one examiner and six other subordinate clerks and employees

Two glimpses inside the United States Patent Office

Seventy-Five Years of American Patent Administration

How the System Has Developed from Small Beginnings, and What It Means to the Nation's Industry

By William I. Wyman

SEVENTY-FIVE years ago the leading industrial country was England. It was in that country that the Industrial Revolution began, due to a series of remarkable inventions of the most fundamental character which originated at about the time of the American Revolution. The inventions by Britishers of the spinning jenny, power loom, reverberatory puddling furnace and steam-engine—all perfected within half a generation—led immediately to the greatest of all changes in civilized history.

The Industrial Revolution and Human Nature

The Industrial Revolution did everything but change human nature. It radically altered politics and history, and did a great deal to modify the appearance of old Mother Earth herself. England, the scene of this revolution, was its first beneficiary, and three-quarters of a century ago its predominance in industry, commerce and wealth was uncontested. The United States was just feeling its way then in manufacturing and machine production. But in the infancy of its industrial life this country presented a radically new system of patent procedure and protection, which tended powerfully to stimulate ingenuity and advance the United States to the foremost place in invention and manufacture. England originated the patent system, her inventions which caused the Industrial Revolution gave strength and body to the system and in turn made it the occasion for the development of the new era. The United States act of 1836, devised by Senator John Ruggles of Maine, constituting the so-called American method of granting patents, was the first vital departure from English patent laws. This act instituted the present organization of the United States Patent Office nine years before the founding of the SCIENTIFIC AMERICAN and in that short time demonstrated its virtues and possibilities.

The law it superseded and the prevailing procedure in all other industrial countries were based upon the "registration" system of granting patents without scrutiny of operativeness, examination of novelty or demonstration of invention. Except as it was made more effective by minor changes, the act of 1836 remains in larger outlines in the law of today; and except for alterations which shall more effectively carry out its purpose and principles, it will persist in the systems of the future. While the law did not fulfil the complete hopes of its creators, it was a pronounced step in the right direction and a decided jump in advance not only of anything that had previously existed, but that had ever been proposed. It was constructive legislation in the highest sense of that abused term. It provided an organization and a mode of procedure for which there were no precedents and presented a positive and clear cut plan for determining patent rights which was absolutely logical and complete and which in its larger outlines provided for every possible contingency. It sharply accentuated the advantages of a proper "examination" system by its vivid contrast with the signal failures of the previously existent "registration" regime. So marked was its success, so closely related to the progress of American industry, so intimately identified with and provocative of the genius of invention, that the so-called American method of granting patents became the standard practice for the whole world to emulate or admire. The only notable exception to this trend, the only highly progressive and powerful state which adheres in entirety to he old "registration" system, is France. And while there may be no necessary connection between her industrial position and her patent system, it is a fact that she has lost relatively in recent years in the international race for economic precedence. And this in spite of the fact that no people are more ingenious, more original in conception or bolder in action. Even staid, conservative England has compromised and accepted partially the advantages of the examination system. The first country to be industrialized, the first to feel the impulse due to invention, the country to whom the greatest fundamental inventions of modern times are due, England had every reason to remain content with her centuries-old patent system. But she was being passed in the race by the newer industrial nations and she was compelled to alter her system in accordance with the methods which were conferring ascendency upon her competitors.

Property in Ideas

For the first time in all history the means for ascertaining and decreeing rights of property in ideas and promoting the objects of a system of patent protection was placed on an intelligent, scientific and adequate basis. Before this time, it was true that some measure of examination prior to the grant was indulged in. In Massachusetts and Connecticut, long before the Revolutionary War, patents were granted by the legislative bodies after a conference with the inventor and a scrutiny of the invention, while under the act of 1790 the Federal Government did the best it could to ascertain utility and the state of the art, but the efforts in these various directions to give valid basis for the patent were spasmodic and fragmentary. No facilities, organization or body of adequate law was ever provided before this time properly to initiate and carry on the "examination" system. This act provided a means for collecting the art, a personnel sufficiently trained to examine the same intelligently, and the machinery and procedure for scientifically endeavoring to give effect to the purpose of the law. That purpose was to throw on the Office the burden which the courts had alone performed, to determine the utility, novelty and patentability of the invention when and where the patent is granted, and, as one writer puts it, "To eliminate litigation 'before it begins.'"

The law of 1836 provided a dignified procedure, gave the grant a *prima facie* standing of validity, and if it did not start this country on its unprecedented industrial era, was at least the most powerful agent in stimulating inventive genius and conserving its fruits. Industrial civilization and invention are inseparable factors. One cannot be comprehended without the other. The present law may be defective and the means to administer it may be inadequate, but the fundamental principles upon which it is based are sound It only needs that it be improved in such detail as necessity indicates to make it the effective instrument that Senator Ruggles perceived it to be for the promotion of the comforts, well-being and progress of a civilized state.

The Patent Office Building, the erection of which was begun in 1836 and finished in 1840. This original structure forms the F Street wing of the present building

The first commissioner of patents and the man who inaugurated the system under the act of 1836 was Henry L. Ellsworth. During his administration the vulcanization of rubber and the electric telegraph were invented and patented. In the short nine years preceding the 75-year era under discussion such a stimulus was given inventions by the new act as to excite the utmost admiration and wonderment of the Commissioner as he was about to retire from office. In the birth-year of the SCIENTIFIC AMERICAN, the second Commissioner of Patents, Edmund Burke, assumed office, so that the life of this publication is almost coextensive with that of the modern patent system.

A great deal of the early reports of the Commissioners was devoted to presenting agricultural statistics and information interesting to tillers of the soil. By law, the Commissioner of Patents was charged with this duty. Since that time, this activity became vested in a separate bureau and later in a department, while the office to which it was originally an appendage is still an obscure subsidiary to an organism to which it has no functional relationship.

The Rush of Patent Business

Even in the earliest days of the history of the office, the condition which has since become chronic, manifested itself. In one of his reports, Commissioner Burke complains: "The office is seven or eight months in arrears of its business and is daily becoming more and more embarrassed. Thus, I have in five separate communications to Congress and its appropriate committees within the last two years made full expositions of the embarrassed condition of this office growing out of its greatly increased and increasing business and the inadequacy of its force to perform its duties."

The fact is that the business presented to the Patent Office has always run ahead of its facilities of performance. Public opinion has failed to recognize the stimulating effect upon invention produced by the patent system and the excessive demands made in turn upon the office by the production of such stimulus. There has been a constant lag between the necessity of giving the office support and the furnishing of the required assistance.

In 1851, in the annual report of the Commissioner, were published the beginnings of the present Rules of Practice. In that year, also, the reviews of the advances in the arts by the examiners were omitted in the annual reports. These reviews were comprehensive summaries of the inventions patented during the year and were attempts to appraise and analyze the different contributions of the patentees. They indicated much labor and enthusiasm and gave testimony to the extreme regard the examiners must have taken in their pursuits and the wide scope of their interests.

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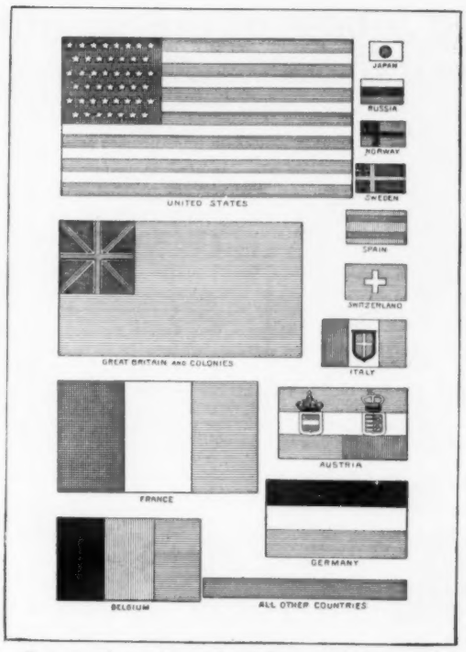

Comparative volume of patents granted by various countries, shown by the relative sizes of the flags, up till the time of the world war

Immediately after the Civil War, the business of the office increased by leaps and bounds. It was a period also of questionable practices and moral lapses in both politics and business, and the Patent Office fell under the spell of prevailing influences. In 1869 Colonel Samuel S. Fisher was appointed, through the recommendation of the Secretary of the Interior Cox, Commissioner of Patents. Colonel Fisher inherited a condition arising from maladministration and rapid growth of the business of the office. He was Commissioner for but one and one-half years, and, although his administration was one of the shortest, it was by far the most fruitful of accomplishment in the history of the office.

Before he entered the Patent Office, chaos had descended upon its administration; its procedure was unscientific, unstable and hopelessly involved; its conclusions uncertain and disturbing; while its functions generally were performed inefficiently and with exasperating dilatoriness. Charges were openly made of favoritism in its conduct, while the public could not free itself of suspicions of dishonesty attaching to its methods.

A Critical Period

He first addressed himself to the task of improving the personnel of the examining corps. As the so-called "American System" of granting patents is based upon a consideration of the prior art, it is evident that its efficiency is dependent upon the character and qualifications of the men who make the examination. This aspect is the vital factor in the whole theory. Commissioner Fisher sensed its importance at once, and proceeded to introduce a system of selecting appointees which was based solely upon the fitness of the candidates for the designated position. As he stated in his Annual Report for 1869, referring to the qualifications of examiners, "It becomes very important, therefore, to secure competent men for positions of such responsibility. An examiner should be a man of great patience, industry and honesty, of varied and yet thorough mechanical and scientific attainments, with a good knowledge of patent law, and a mind capable of the nicest discrimination. Though many men offer themselves for the position, but few are fit to fill it."

The tests he constituted were probably the first ever established for entrance into the Civil Service that were rigid, searching and competitive in character. They comprised all the elements of the modern merit system and anticipated its general introduction by almost a generation. It was only through the opposition of a public-spirited official now and then who chanced to be in power and who dared to interpose that the logical result did not intervene and disrupt the whole administration of government. One such official was Gov. J. D. Cox, Secretary of the Interior, who had induced Colonel Fisher to accept the Commissionership. The latter knew only too well how important to the industrial interests it was that the work of the office should be conducted by men of technical and scientific capacity and of high character. And in his efforts to provide a personnel of the desired attainments, he was supported without qualification by his immediate superior.

The result of Commissioner Fisher's policy was shown in the character of the new members of the corps, who in all the requirements of the position readily demonstrated a superiority over those in office who had come in under the old order. Secretary of the Interior Cox, who was a powerful barrier to the progress of many a corrupt influence and who was most anxious to improve the methods of government administration, gave his testimony of the effect of the new policy in the Patent Office in the following words: "No one could become even superficially acquainted with the organization of that important bureau without seeing that a spirit of emulation and zeal had taken the place of a listless and negligent performance of duty." In reviewing the history of those days, one cannot but help noting how far we have advanced in the ethics of government administration. Those who are despairing of the capabilities and rectitude of the office-holding class have no basis for their pessimism. On the contrary, there is good ground for optimism. A most casual comparison of conditions then and now shows an immense improvement in the personnel, both in efficiency and honesty, and a decidedly more wholesome atmosphere.

Commissioner Fisher and Secretary Cox were mostly responsible for initiating this movement, which led to such important results in improving the standards of public taste and executive

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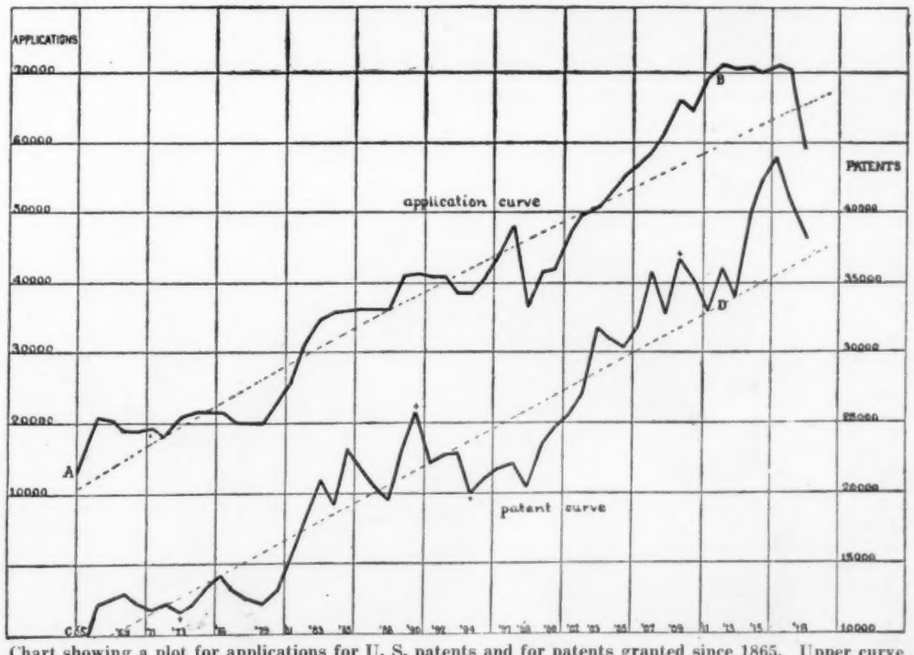


Chart showing a plot for applications for U. S. patents and for patents granted since 1865. Upper curve represents applications for patents and re-issues, and lower one represents patents granted excluding re-issues. Dotted lines represent what might be called the lines of normal increase

Left: A corner of the Patent Office, showing how thousands upon thousands of documents are filed away for reference purposes. *Right:* An examiner's room in the Patent Office. It is interesting to note that in 1836 the Patent Office became an independent bureau, headed by a commissioner, assisted by one examiner and six other subordinate clerks and employees

Two glimpses inside the United States Patent Office

Seventy-Five Years of American Patent Administration

How the System Has Developed from Small Beginnings, and What It Means to the Nation's Industry

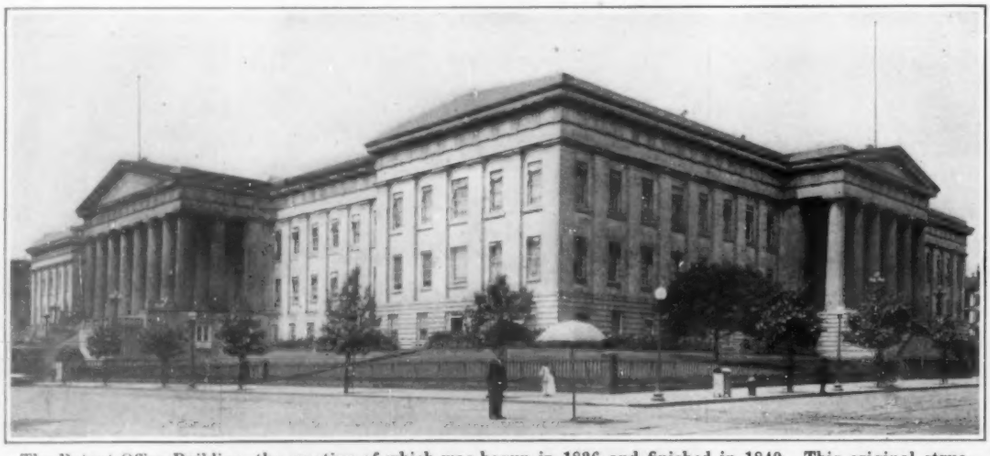
By William I. Wyman

SEVENTY-FIVE years ago the leading industrial country was England. It was in that country that the Industrial Revolution began, due to a series of remarkable inventions of the most fundamental character which originated at about the time of the American Revolution. The inventions by Britishers of the spinning jenny, power loom, reverboratory puddling furnace and steam-engine—all perfected within half a generation—led immediately to the greatest of all changes in civilized history.

The Industrial Revolution and Human Nature

The Industrial Revolution did everything but change human nature. It radically altered politics and history, and did a great deal to modify the appearance of old Mother Earth herself. England, the scene of this revolution, was its first beneficiary, and three-quarters of a century ago its predominance in industry, commerce and wealth was uncontested. The United States was just feeling its way then in manufacturing and machine production. But in the infancy of its industrial life this country presented a radically new system of patent procedure and protection, which tended powerfully to stimulate ingenuity and advance the United States to the foremost place in invention and manufacture. England originated the pateht system, her inventions which caused the Industrial Revolution gave strength and body to the system and in turn made it the occasion for the development of the new era. The United States act of 1836, devised by Senator John Ruggles of Maine, constituting the so-called American method of granting patents, was the first vital departure from English patent laws. This act instituted the present organization of the United States Patent Office nine years before the founding of the SCIENTIFIC AMERICAN and in that short time demonstrated its virtues and possibilities.

The law it superseded and the prevailing procedure in all other industrial countries were based upon the "registration" system of granting patents without scrutiny of operativeness, examination of novelty or demonstration of invention. Except as it was made more effective by minor changes, the act of 1836 remains in larger outlines in the law of today; and except for alterations which shall more effectively carry out its purpose and principles, it will persist in the systems of the future. While the law did not fulfil the complete hopes of its creators, it was a pronounced step in the right direction and a decided jump in advance not only of anything that had previously existed, but that had ever been proposed. It was constructive legislation in the highest sense of that abused term. It provided an organization and a mode of procedure for which there were no precedents and presented a positive and clear cut plan for determining patent rights which was absolutely logical and complete and which in its larger outlines provided for every possible contingency. It sharply accentuated the advantages of a proper "examination" system by its vivid contrast with the signal failures of the previously existent "registration" regime. So marked was its success, so closely related to the progress of American industry, so intimately identified with and provocative of the genius of invention, that the so-called American method of granting patents became the standard practice for the whole world to emulate or admire. The only notable exception to this trend, the only highly progressive and powerful state which adheres in entirety to he old 'registration" system, is France. And while there may be no necessary connection between her industrial position and her patent system, it is a fact that she has lost relatively in recent years in the international race for economic precedence. And this in spite of the fact that no people are more ingenious, more original in conception or bolder in action. Even staid, conservative England has compromised and accepted partially the advantages of the examination system. The first country to be industrialized, the first to feel the impulse due to invention, the country to whom the greatest fundamental inventions of modern times are due, England had every reason to remain content with her centuries-old patent system. But she was being passed in the race by the newer industrial nations and she was compelled to alter her system in accordance with the methods which were conferring ascendency upon her competitors.



The Patent Office Building, the erection of which was begun in 1836 and finished in 1840. This original structure forms the F Street wing of the present building

Property in Ideas

For the first time in all history the means for ascertaining and decreeing rights of property in ideas and promoting the objects of a system of patent protection was placed on an intelligent, scientific and adequate basis. Before this time, it was true that some measure of examination prior to the grant was indulged in. In Massachusetts and Connecticut, long before the Revolutionary War, patents were granted by the legislative bodies after a conference with the inventor and a scrutiny of the invention, while under the act of 1790 the Federal Government did the best it could to ascertain utility and the state of the art, but the efforts in these various directions to give valid basis for the patent were spasmodic and fragmentary. No facilities, organization or body of adequate law was ever provided before this time properly to initiate and carry on the "examination" system. This act provided a means for collecting the art, a personnel sufficiently trained to examine the same intelligently, and the machinery and procedure for scientifically endeavoring to give effect to the purpose of the law. That purpose was to throw on the Office the burden which the courts had alone performed, to determine the utility, novelty and patentability of the invention when and where the patent is granted, and, as one writer puts it, "To eliminate litigation 'before it begins.'"

The law of 1836 provided a dignified procedure, gave the grant a *prima facie* standing of validity, and if it did not start this country on its unprecedented industrial era, was at least the most powerful agent in stimulating inventive genius and conserving its fruits. Industrial civilization and invention are inseparable factors. One cannot be comprehended without the other. The present law may be defective and the means to administer it may be inadequate, but the fundamental principles upon which it is based are sound It only needs that it be improved in such detail as necessity indicates to make it the effective instrument that Senator Ruggles perceived it to be for the promotion of the comforts, well-being and progress of a civilized state.

The first commissioner of patents and the man who inaugurated the system under the act of 1836 was Henry L. Ellsworth. During his administration the vulcanization of rubber and the electric telegraph were invented and patented. In the short nine years preceding the 75-year era under discussion such a stimulus was given inventions by the new act as to excite the utmost admiration and wonderment of the Commissioner as he was about to retire from office. In the birth-year of the SCIENTIFIC AMERICAN, the second Commissioner of Patents, Edmund Burke, assumed office, so that the life of this publication is almost coextensive with that of the modern patent system.

A great deal of the early reports of the Commissioners was devoted to presenting agricultural statistics and information interesting to tillers of the soil. By law, the Commissioner of Patents was charged with this duty. Since that time, this activity became vested in a separate bureau and later in a department, while the office to which it was originally an appendage is still an obscure subsidiary to an organism to which it has no functional relationship.

The Rush of Patent Business

Even in the earliest days of the history of the office, the condition which has since become chronic, manifested itself. In one of his reports, Commissioner Burke complains: "The office is seven or eight months in arrears of its business and is daily becoming more and more embarrassed. Thus, I have in five separate communications to Congress and its appropriate committees within the last two years made full expositions of the embarrassed condition of this office growing out of its greatly increased and increasing business and the inadequacy of its force to perform its duties."

The fact is that the business presented to the Patent Office has always run ahead of its facilities of performance. Public opinion has failed to recognize the stimulating effect upon invention produced by the patent system and the excessive demands made in turn upon the office by the production of such stimulus. There has been a constant lag between the necessity of giving the office support and the furnishing of the required assistance.

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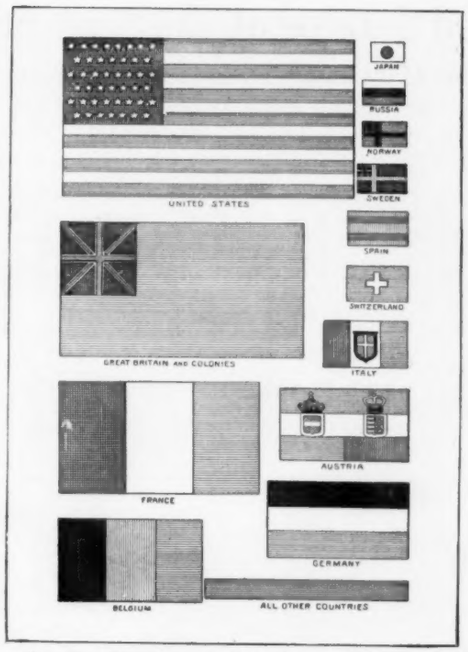

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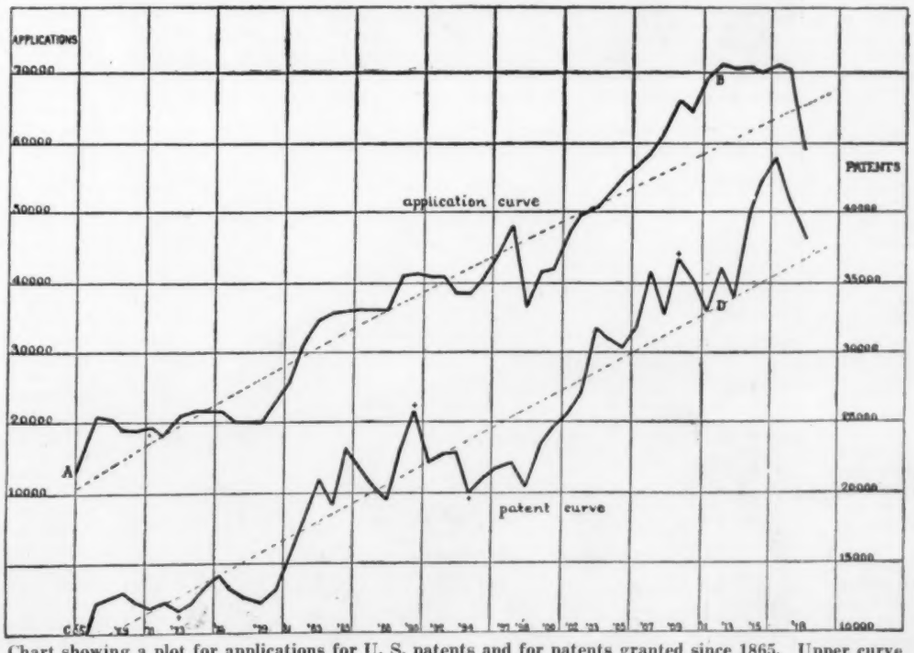

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The Diamond Jubilee of the Scientific American

Three Quarters of a Century's Service to the Cause of Invention and Popular Science

Alfred Ely Beach,
a founder of Munn & Co.

SEVENTY-FIVE years ago occurred an event which was to set its unalterable imprint on the history of American invention and American progress — the founding of the SCIENTIFIC AMERICAN. It is doubtful if there are ten other periodicals which can boast so long a life. "Long life" is here used advisedly; for, at the end of seventy-five years we find the same ideals, the same devotion to the production of an accurate scientific and technical newspaper. This publication first started the idea of a service department, and nearly a million readers have asked for information, and rarely have they been disappointed. "Service" is, in fact, the keynote of the success of the SCIENTIFIC AMERICAN; for the cardinal idea is to conduct the paper in such a manner that it shall be of the highest possible benefit to the business man, the inventor, the manufacturer, and the general reader.

From time to time we get requests from institutions of learning for information relative to the early history of the SCIENTIFIC AMERICAN, for class study. This is the highest compliment which can be paid, and it is to give material of like nature that the present brief article is penned.

We celebrate in this issue the founding of the SCIENTIFIC AMERICAN, which took place in 1845. The journal was a weak and puny affair, however, when it was purchased by Orson Desaix Munn and Alfred E. Beach for a few hundred dollars in 1846. The paper was conducted by them as long as they lived, and since then by the descendants of the former partner.

It is logical that the first office should be in the "Sun" building; for the proprietor of that virile paper was Moses Yale Beach, father of Alfred Ely Beach. The first beginnings were small, the page being about twice the size of the present SCIENTIFIC AMERICAN, the whole paper consisting of only four pages. What we call the "net printed edition" was easily carried to the Post Office by one of the two enthusiastic founders. Journals of any kind were a rarity, and a scientific paper a wonder. The slogan of the first issue was that the "SCIENTIFIC AMERICAN is the advocate of industry and the journal of mechanical and other improvements."

Apparently there was not much industry to advocate or many mechanical improvements to record; for the editor found space enough to publish poetry, dissertations on temperance, and brief articles on such curious topics as "The Utility of Tribulations," "The Influence of Fashion," "Street Beggars," "Oriental Servility," and "Church Benevolence." When the SCIENTIFIC AMERICAN was first published the great achievements of the century were Davy's discovery of the electric arc light and of electrolysis; Oersted's and Ampere's electro-dynamic discoveries; Daguerre's method of photographing; Henry's and Faraday's discoveries in induction; and Joule's determination of the mechanical equivalent of heat.

Some of the advertisements afford interesting reading today and are interwoven with the warp and woof of progress. Advertising increased so that an apology was printed for carrying two and one-half columns! Eight lines cost only 50 cents—payable in cash, let us hope. Advertisements could not exceed 16 lines, and cuts could not be inserted at any price whatever.

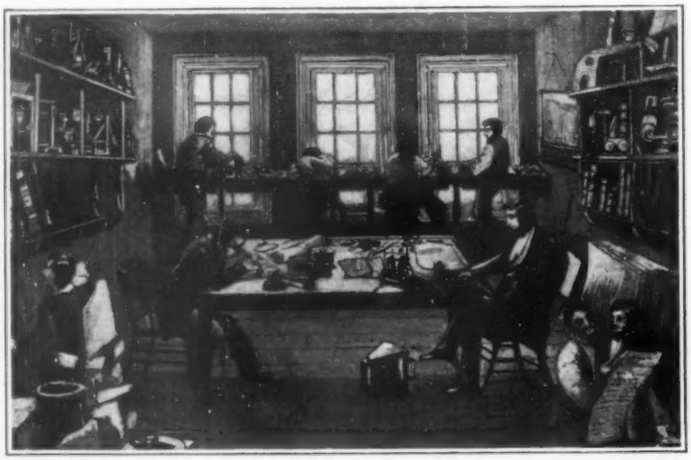
How the Patent Department Was Created

Because it was the only scientific paper of its kind the offices soon became a meeting place for inventors. Out of this intimate relation sprang the necessity of creating a special department for inventors, a department to give advice on the patenting of inventions and on patent law. From its very inception that department has proved the most successful patent bureau ever established. Among its clients have been such distinguished men as Samuel F. B. Morse, inventor of the telegraph; Elias Howe and A. B. Wilson, famous for their sewing machine inventions; Capt. James B. Eads, the distinguished builder of the great Mississippi bridge; Capt. John Ericsson, the designer of the "Monitor"; Dr. R. J. Gatling, inventor of the Gatling gun; Peter Cooper Hewitt, inventor of the mercury arc light; Thomas A. Edison, and others too numerous to mention.

Although the partners of Munn & Co. are members of the Bar, the law practice before the Courts is conducted by an associate firm under the name of Munn, Anderson & Munn.

Orson Desaix Munn,
a founder of Munn & Co.

United States Patent Office and Munn & Company's first office in Washington
(From an old print of 1859)



Patent Department of Munn & Company in 1849 (From a contemporary print)

The Scientific American offices at 37 Park Row, from 1859-1882

The Scientific American and Inventors

Many of the disclosures are of historic importance for example take A. B. Wilson, who came to New York from Pittsfield, Mass., amid the derision of his neighbors. He came to the offices of Munn & Co., who secured for him a patent which served as the foundation stone for the great Wheeler and Wilson industry, and the world first heard of it through the SCIENTIFIC AMERICAN of November 24th, 1849. In his early days came Thomas A. Edison, and in 1877 he one day appeared with a small package which on being opened proved to be a machine and announced itself by saying: "Good morning. How do you do? How do you like the talking box?" The story of "Mary and Her Little Lamb" is not apocryphal, but Mr. Edison's favorite began "A soldier of the Legion lay dying in Algiers." The SCIENTIFIC AMERICAN Editors were among the first to see the electric incandescent lamp; the Edison dynamo, and the kinetoscope, and a score of other interesting inventions.

The inventions of Mr. Alfred E. Beach must not be passed by as they were of considerable importance and included one of the first successful typewriters, and the tunnelling shield which made possible his Broadway tunnel that was built exactly where trains now hurtle through and in and out of the City Hall Subway station on their way to the outlying boroughs. "Rapid transit" was evidently a problem as early as 1845, but 1870 saw the fruition of their dream. The short experimental tunnel was only a block long; but the cars actually ran. It was reserved for electricity to make subway traffic a commercial reality. Probably the pneumatic system would have been a failure, but this idea for rapid transit was thirty years ahead of the times. Thanks to the then all-powerful Tammany Hall, the scheme was defeated and elevated railways were built instead, much to the wrath of the Editor.

The SCIENTIFIC AMERICAN advocated better railways and helped to mold public opinion to such great undertakings as a line linking the Atlantic and Pacific coasts. The Panama Canal was also advocated as far back as 1846.

In 1845 the SCIENTIFIC AMERICAN began publishing articles on the automobile, such as it was then, and year after year space was given to the ideas of inventors who, groping in the blackness of futurity still had a clarity of vision which was phenomenal. It was through the SCIENTIFIC AMERICAN that they learned of the successes, trials, and failures of the pioneers, such as Cugnot, Trevithick, Church and Lénoir. When, at last, in invention's own time the automobile *did* appear it seemed to the readers not like a sudden apparition, but a vehicle with which they had always been familiar. Aerial navigation early fascinated the readers, even

from the first numbers, so that, for over fifty years it was the only periodical that took the airship and airplane seriously. Impractical ideas were freely criticised, and great sums of money were saved by honest advice which often resulted in the abandonment of useless plans.

The Scientific American Airplane Trophy

With the object of fostering the art of aerial navigation, the SCIENTIFIC AMERICAN offered a magnificent trophy, which is illustrated herewith, under the auspices of the Aero Club of America, and on July 4th, 1908, Mr. Glenn H. Curtiss won the trophy for that year for flying a distance slightly more than a mile in his biplane, "The June Bug," which is illustrated elsewhere. In 1909 Curtiss again won the cup for flying a distance of 25 miles in a closed circuit, and in 1910 he won the cup for the third and last time in connection with his flight from Albany to New York, when he covered a straight away distance of 74½ miles without stop, which was phenomenal in those days. Mr. Curtiss having won the competition for three years secured permanent possession of the trophy.

Scientific American Trophy for heavier-than-air flights, won by Glenn H. Curtiss

The Scientific American and Its Subscribers

From the very inception of the SCIENTIFIC AMERICAN the editor and the subscribers have been more closely associated than is usual, even in these days of paternal magazine editing. The periodical was always regarded by the publishers as something more than a mere commercial venture. They have always felt that they owe a duty to the subscribers, and a duty that did not end in giving an amount of printed matter equivalent in value to the price of an annual subscription. Accordingly, no letter asking the editor for information is allowed to go unanswered. Often the response entails an amount of research worth many times the amount of the subscription.

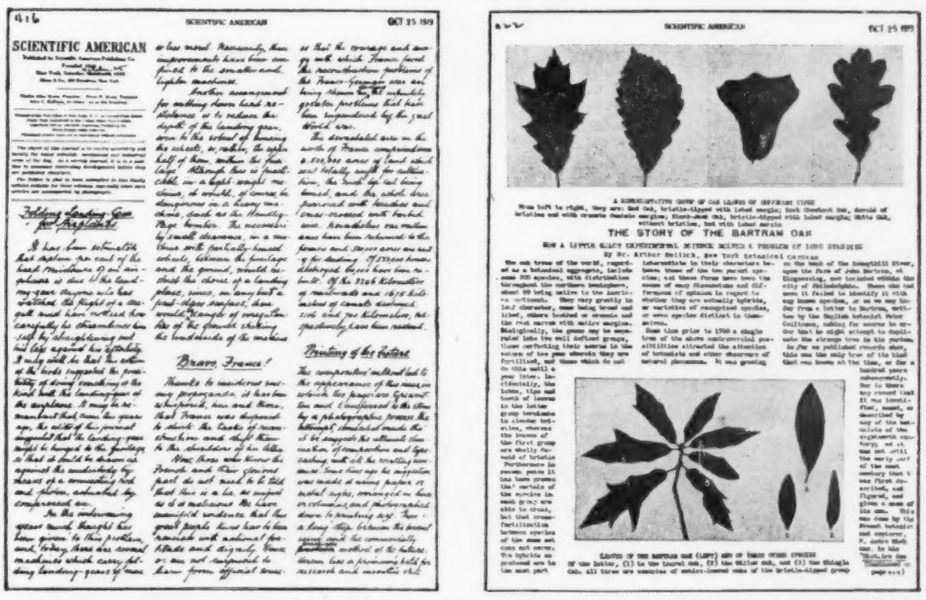
The Scientific American as an Educator

For several decades the SCIENTIFIC AMERICAN stood practically alone in the particular field which it covered. Launched in a new country, destitute of great libraries, great museums, or great universities, it served to a limited degree, it may be, but with distinct success, the purposes of all three. Not a few of the men who stand at the head of the great industrial institutions of the United States recall the hopeful days of their boyhood and their young manhood, when their chief source of instruction in the great happenings of that world in which they were about to make venture was the SCIENTIFIC AMERICAN.

THE ILLUSTRATED LONDON NEWS, Dec. 6, 1919.—921

FIGHTING A PRINTERS' STRIKE WITH THE TYPE-WRITER: A CURIO.

By Courtesy of the "Scientific American."



WITH AN EDITORIAL IN LONGHAND AND OTHER LETTERPRESS IN TYPE-WRITING: PAGES FROM A LITHOGRAPHED NUMBER OF THE "SCIENTIFIC AMERICAN" PUBLISHED DURING A STRIKE OF NEW YORK PRINTERS.

Owing to a strike of printers in New York, over a demand for increased pay, many American papers recently had to suspend publication. The "Scientific American," however, which has never missed an issue in 74 years, adopted an ingenious plan to avoid doing so. A prefatory note in the issue for October 25, four pages from which are reproduced above on a reduced scale, says: "The copy has been prepared by the editors on their trusty typewriters; and from this copy photographic transfers have been made on a lithographic stone. . . . We believe that this is the first time it (lithography) has ever been used in this manner, to produce the inside of an ordinary magazine. In this process the entire page becomes in effect a single illustration. . . . We present the editorial page in direct reproduction of the original long-hand manuscript by the senior member of the staff." Some of the stock advertisements appeared in ordinary print, but these were already set up in type before the strike.

How the Scientific American got along without compositors and pressmen during the printers' strike of the autumn of 1919

Thousands of men who are now engineers and manufacturers received their first inkling of mechanical or electrical engineering from the pages of the SCIENTIFIC AMERICAN. Thomas A. Edison has related that as a boy he used to walk three miles to the post office every week to get his SCIENTIFIC AMERICAN. For seventy-five years issue after issue has explained with a simplicity that has appealed to every earnest student unfamiliar with the phraseology of more technical periodicals and books how apparatus of all kinds are constructed, and how such devices operate.

Exposing Swindlers

As the SCIENTIFIC AMERICAN ministered to the intellectual requirements of a pre-eminently practical nation, so it guarded its financial interests when they involved science or machinery. Swindling schemes, based on supposedly revolutionary inventions, are encountered with less frequency than formerly, chiefly because we have a large class of trained technical men to fall back upon for expert advice. Thirty-five years ago it was otherwise. The late John W. Keeley, of blessed memory, who talked with the glib obscurity of an Indian Swami and was possessed of the audacity of a Cagliostro, was the prince of these swindlers. Year after year the SCIENTIFIC AMERICAN ridiculed his "etheric vapor," his vibrators, his resonators, and the mysterious forces that served to discharge his etheric weapons and to operate his engines. The editor took the trouble to build a duplicate of Keeley's "etheric gun," to prove that it was operated by compressed air. When Keeley died in 1899, still gaining the ears of a rapidly dwindling public, still living on the spoils of the mechanically ignorant and credulous, the SCIENTIFIC AMERICAN made a thorough examination of his laboratory at 1420 North Twentieth Street, Philadelphia. Every piece of flooring was torn up ruthlessly and every nook and cranny searched. The investigation turned out exactly as the SCIENTIFIC AMERICAN had predicted twenty years previously. Keeley's "etheric vapor" proved to be compressed air, and the man was proven to be a charlatan. There were other schemes besides Keeley's—all of them forgotten now, but as alluring to the unwary investor. In exposing them the SCIENTIFIC AMERICAN probably saved many a reader from serious financial loss.

The Scientific American and the War

For two or three years prior to the terrible catastrophe of 1914, the editors had been very much interested in "preparedness," and had quietly amassed a fund of information and valuable data which was to prove of much use in the troublous years to follow. Scarcely had the cables announced the fateful news that Europe was aflame, than preparations were begun to treat the war in an accurate and scientific manner, and every member of the staff threw himself into the work with the greatest enthusiasm. The famous "War Numbers" are still preserved in libraries as among the most valuable of written memorials of the world-war. The sale of the earlier War Numbers was enormous, and helped to educate an entire people into the serious business of war, which was so little understood and which was so vitally necessary. The number of illustrations on war subjects went into thousands, and the best talent in the way of professional soldier and sailor writers was obtained. The entire collection of these thousands of pictures has been given to Princeton University, and the process of transfer is still going on.

Our entry into the war resulted in even greater efforts to inform the American people, and the editorial rooms of the SCIENTIFIC AMERICAN became a great clearing house where meritorious inventions and devices were speeded to the proper governmental agencies, and the merely chimeric plans were discouraged.

Labor Troubles Are Overcome

Perhaps the most serious mishap the SCIENTIFIC AMERICAN suffered in all the seventy-five years of its existence was the printers' strike in the autumn of 1919. The compositors ceased working almost without notice after the pressmen had struck. If the compositors had not struck it would have made very little trouble; for we were calculating on working the paper by lithography, using the "offset" process for both type and illustrations. Our hopes were blasted, however, when type could not be set. Our editors' minds moved quickly, and in a surprisingly short space of time they evolved a plan which made typesetting in the emergency unnecessary. The matter was first "roughed out" on a typewriter, so that the approximate amount of space could be allotted, and then it was retyped with the same care as a hand compositor used in justifying his lines and spaces. Troublesome "run-rounds" were conquered and even the "fuzziness" of the textile ribbon was obviated by the sub-

(Continued on page 388)

Present Washington building of Munn & Company and the Scientific American

Faith

MEMORY sometimes swings back to days when the automobile was nothing but "another crazy idea." When the few who took it seriously were objects of the misplaced sympathy of friends, and of unfriendly comment by the general public. When the legal rate of speed in many big cities was not to exceed seven miles an hour. When the man whose horse ran away at the sight of a horseless carriage always had the jury with him.

Those early days mean something to us now because to believe in the future of the atuomobile meant a great deal, then. To point a business in a new direction, seaward without a compass, took something more than courage and resource. It took the same vision, the same purpose, that were actuating those who were spending their days in the shop and their nights at the drawing board, producing the very beginnings of a new kind of transportation. It took *faith!*

During the last score of years the automobile industry has made a place for itself from which it can never be dislodged. It has done something more than develop a new mechanism to serve convenience,

TIMKEN

or whim. *It has produced a new and fundamental transportation method, whether for people or things.*

It has made a daily contribution to the health and welfare of every person who lives in the civilized world. It has made Better Service between men, and between peoples, a fact instead of a theory. It has justified the faith of those who saw in it an agency that would realize the dream of a *Railway Without Rails.*

The reliable passenger car and truck builders, and every manufacturer who produces good equipment for their completion, are in the same business as the railroads. It has taken hard work, a lot of it unseen and unsung, to put them there. Most of those who took off their coats in the early days have never had time to put them on again.

The demand has been insistent for automotive transportation that should be increasingly better and more reliable. Each unit of the industry has had to organize for service. Engineering has made tremendous strides. Production methods have evolved that are the wonder even of those intimately concerned with them. Every day has meant twenty-four hours of progress.

Now comes a further development of the fundamental idea, which will make possible machine methods, and larger harvests, on every acre of farm land, cultivated and uncultivated, in the world today. The opportunity for service which lies before the tractor industry is as magnificent as any American business has ever faced.

It seems a long way back to the days when most people were saying, "the automobile will never work." *But we remember when faith in our product was all we had with which to anticipate the refined, fast-moving, powerful motor vehicle.*

Manufacturers of automobile, truck, and tractor have already surmounted their gravest difficulties. Commerce and industry, and the individual, recognize that the usefulness of the self-propelled vehicle has established it as a utility, and as an essential. The world can no longer get along without it.

Faith today is founded on fact!

THE TIMKEN ROLLER BEARING CO., Canton, Ohio

Plants manufacturing complete bearings at
Canton, O.; Columbus, O.; Birmingham, Eng.; Paris, France
General Offices, Steel, Rolling, and Tube Mills, Canton, O.

Timken Tapered Roller Bearings for Passenger Cars, Trucks, Trailers, Tractors, Farm Implements, Machinery, and Industrial Appliances

BEARINGS

From Wet Plate to Motion Pictures

Some of the Milestones That Accentuate the Development of Amateur and Professional Photography

IT required an exposure of six minutes in strong sunlight to make a portrait of Miss Dorothy Catherine Draper. But that was in 1840, and her's was the first photograph of a human face. Compare that achievement, by Prof. John William Draper, with the remarkable snapshots made by anyone with a two-dollar box camera today, and you have a condensed summary of the development of photography during the past four score years.

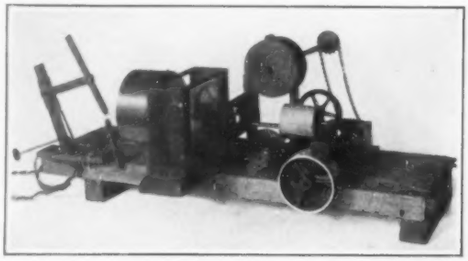
Photography does not start with the work of Professor Draper, nor does it start with Daguerre. Indeed, the origin of photography, or more correctly the origin of the camera, dates back to the middle of the sixteenth century when an Italian philosopher, Battista Porta, exhibited his *camera obscura* to the crowds that flocked to his house in Naples. All he did was to put a tightly-fitting shutter on his window, so that no light could enter except by a small hole which he had cut in the center of the shutter. He did not use a lens; yet the rays of light entering the room showed an inverted image of outdoors on the opposite side of the room. And even Porta's *camera obscura* is not the first attempt at the camera principle, for there are records of previous experiments of this kind.

At any rate, the *camera obscura* was the basis of photography. There remained the problem of recording the image in some suitable manner so that it might be made permanent.

So it may be said that photography proper starts with the work of Joseph Nicéphore de Niepce, who has been called the father of the art. His process appeared in 1824. In the Niepce process a silver-faced copper plate was coated with asphalt dissolved in oil of lavender and dried. It was then exposed to light in the camera, or in the case of an engraving, by superposition. Thereupon it was washed over with a combination of one part of oil of lavender and ten parts of petroleum. The picture was next rinsed in water and dried, preparatory to being placed in an iodine fuming box until the bright silver ground turned black. On removing the part of the asphalt remaining, the lights and shadows of the picture appeared in their proper relation, or instead, the plate was etched and printed as in ordinary etching.

Daguerre—His Process and His Work

Then came Daguerre, whose name is so well remembered whenever photography is mentioned. It was in 1839 that Daguerre published his process. A copper plate, one surface of which had been silvered and highly polished, was fumed with iodine and then exposed in the camera, followed by the development with vapor of mercury and fixing in a solution of hyposulfite of soda. The solvent action of hyposulfite on the silver haloids was discovered by Sir John Herschel. The exposure required about fifteen minutes. Niepce and Daguerre then collaborated in the development of photography, so that some of the credit of having developed the daguerreotype belongs to Niepce.



This projector, exhibited by C. Francis Jenkins, in 1893, contained the essentials of the present-day machine shown at the upper right-hand corner of this page. Note the carbon arc, condenser, sprockets, intermittent movement and general arrangement. A water condenser was used to reduce fire hazard ever present with exposed celluloid film

A pioneer machine which marked the beginning of the modern projector

Soon after this, however, by the addition of bromine to the iodine by Goddard in 1840, and chlorine by Claudet in 1841, the plates were made more sensitive; indeed, in the year 1840 we find Dr. Draper making daguerreotype portraits in from twenty to ninety seconds. It was M. Fizeau who discovered that by treating the daguerreotype with double hyposulfite of soda and gold, it was made more permanent and very much more beautiful.

This camera was the first Daguerreotype apparatus made in the United States, making its appearance in 1839. Focusing was accomplished by having the box made in two sections, one sliding within the other

Compare this early camera with the latest motion-picture camera in the upper left-hand corner

We come next to the calotype or talbotype, the invention of Henry Fox Talbot. Until Talbot's process was published in 1840, there was no such thing as printing in photography; that is to say, but one copy of a picture was made at each sitting, and that was the original exposed in the camera. Talbot introduced the photographic negative from which an unlimited number of prints may be made. According to Talbot's process, a solution of nitrate of silver was prepared, brushed over a sheet of paper, and dried. Then the paper was dipped in a solution of iodide of potassium, washed in water, passed between blotting paper, and dried. This was called iodized paper. When the paper was required for use, it was washed with a solution of nitrate of silver fifty grains, water one ounce, acetic acid one-sixth of an ounce. This was called "Solution A."

"Solution B" was a saturated solution of gallic acid in cold water. The two solutions were mixed in equal parts, just before using. Talbot called this "gallo-nitrate of silver." The iodized paper was treated with this solution and again dried. The paper was then exposed in the camera and developed with the gallo-nitrate of silver and fixed in hyposulfite of soda. Talbot found later that, by waxing, the paper negative was rendered more transparent, so that it gave better results in printing.

The use of collodion as a vehicle to hold the silver haloids upon plates originated with Frederick Scott Archer in 1850, although the idea was suggested by Gray the same year. Albumen paper had already been introduced by Blanquard-Everard in 1848.

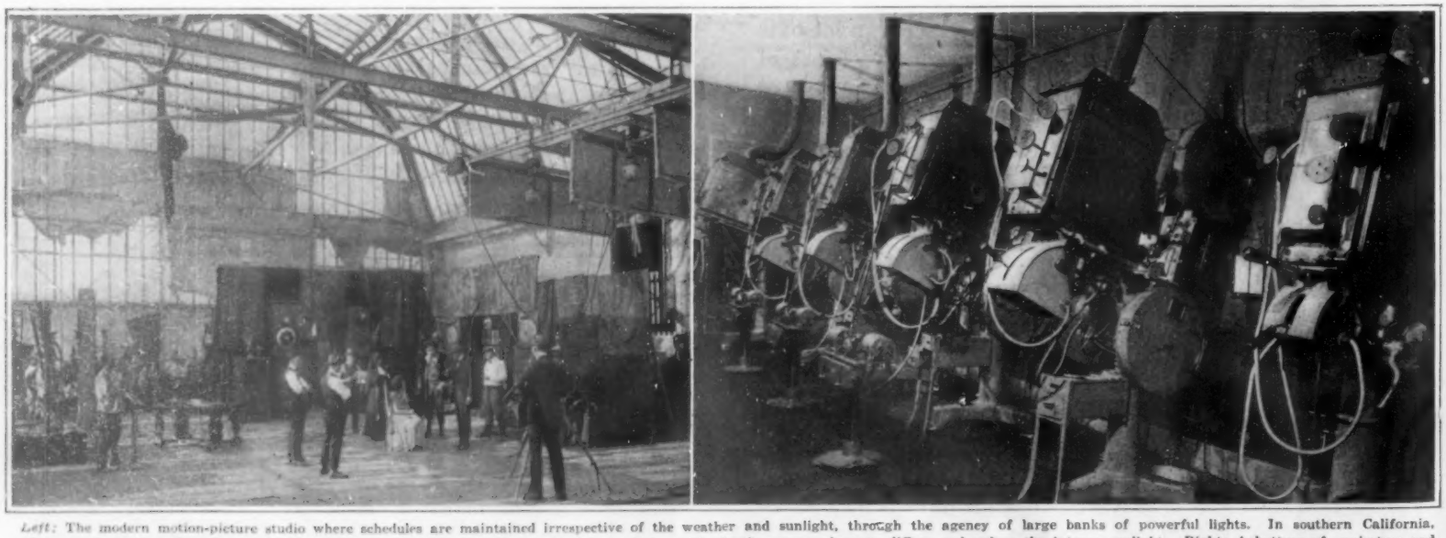
Various photo-lithograph and other printing processes were invented at about this time, with a number of inventors taking part.

Better Prints and How They Came About

George Wheaton Simpson is credited with working out the printing-paper process as early as 1861, using collodion for the purpose. Abney, in 1881, worked out printing paper with gelatine. The present developing papers—papers which, unlike the printing papers, do not show the image until they are properly developed, but which are so much faster and easier to handle, requiring only gas light or electric light in place of sunlight—came some time later. One of the most successful of these papers was that of Dr. Leo H. Baekeland.

Carbon printing in its present form appears to be the product of many minds. Mungo Ponton in the year 1839 discovered that white paper treated with a solution of bichromate of potash darkened when exposed to light. The next was the discovery that gelatine, gum and other bodies were rendered wholly insoluble

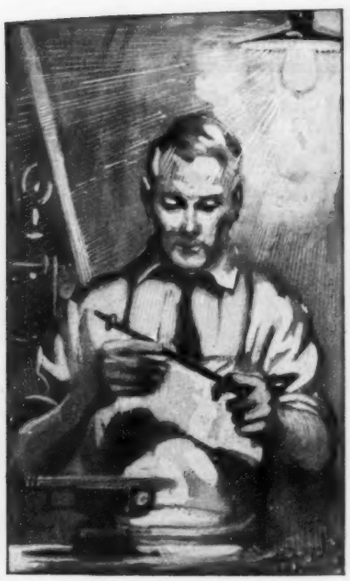
(*Continued on page 366*)



Left: The modern motion-picture studio where schedules are maintained irrespective of the weather and sunlight, through the agency of large banks of powerful lights. In southern California, where good weather abounds throughout most of the year, the studios are outdoor affairs with simple screens above to diffuse and reduce the intense sunlight. *Right:* A battery of projectors and a stereopticon machine in the operator's booth of a leading motion-picture theatre

The motion-picture film from its manufacture to its consumption, or in other words, from studio to screen

How many men in your plant work standing in their own light?



How many men in your plant work under a blinding glare?

How many men in your plant grope for their tools in semi-darkness?

How many men in your plant carry work to windows for fine measurements?

Four Important Questions For Every Employer

Above are four stop-you-in-your-stride questions. If you have not read them, do so now. They have an important bearing on your production, your spoilage and your accidents. If your plant is incorrectly lighted, your net profits are being affected by some or all of the above conditions.

Do you realize that an improperly lighted factory costs *more* for illumination than one that *is* correctly lighted? It's a fact. Tests prove it. Here are the figures. Poor lighting is costing you 12% *less* production, 25% *more* spoilage and 25% *more* accidents. Translate this into dollars and you have a cost many times the price of a complete 100% efficient Benjamin Industrial Illumination equipment. In other words, you are paying more for the doubtful privilege of inadequate illuminating service than you would for the best the illuminating engineering world affords. Can you afford it? We hardly think so.

Benjamin Industrial Illumination has revolutionized the illumination in many of America's foremost plants. It has turned inadequate, expensive lighting into efficient, economical illumination. It can do the same for you. Our Illuminating Engineering Department will gladly co-operate with your engineer, contractor or architect in making recommendations that will secure for you all that modern artificial lighting provides. Further information awaits the asking.

Address Advertising Department, 806 W. Washington Blvd., Chicago

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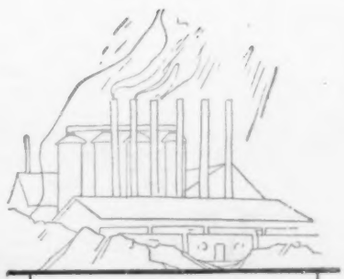

BENJAMIN

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Best in material, lightest in weight, smallest in size; they need little labor in installation. Order Benjamin-Starrett Panel Boards in connection with all correct industrial lighting installations for long, satisfactory service, safety and fine appearance.

Immediate shipments make possible immediate installations.

BENJAMIN PRODUCTS

The following are divisions of Benjamin products on which we will be glad to send information:

Industrial Lighting Division

Electrical Division (including Benjamin Two-Way Plug)

Pressed Steel Products Division

Enameled Products Division

Starrett Panel Board Division

Recently Patented Inventions

Brief Descriptions of Recently Patented Mechanical and Electrical Devices, Tools, Farm Implements, Etc.

Electrical Devices

SWITCH.—J. SCHNEIDER, 412 Walnut St., Roselle Park, N. J. This invention relates to high tension switches of the plunger type. Its object is to provide a disconnecting switch arranged to combine maximum rigidity with minimum of weght and allow of conveniently opening and closing the switch. Another object is to maintain the opening members in perfect alinement when the switch is opened or closed thus insuring perfect electrical contact. Another object is to protect the contact making parts from moisture, dust, or other extraneous matter and to render the plunger self-cleaning.

THERMAL CIRCUIT CLOSER. — W. P. WEBBER, 147 Hancock St., Brooklyn, N. Y. An object of the invention is to provide a heat-controlled fire alarm device which may be conveniently held either in a vertical, horizontal or any intermediate position such as on a ceiling or side wall, so that said device will be responsive to a predetermined increase of temperature either within a room or between the walls or ceiling or partitions, to cause an electric circuit to be completed.

Of Interest to Farmers

PLANTER.—F. H. SCHUTTER, Pleasant Valley, Iowa. The invention relates more particularly to planters for planting onion sets. An object is to provide means whereby a great number of onion sets can be planted in a relatively short space of time. A further object is to provide an onion planter that is simple in construction, efficient in operation and one that can be cheaply made.

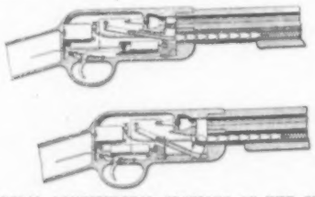
AGRICULTURAL IMPLEMENT. — R. B. MASON, 19 West Patriot St., Somerset, Pa. The invention is adapted for use with a threshing machine. It consists of a sheaf loader adapted to travel over the ground and gather the sheaves into a container. A sheaf distributer receives the sheaves when the loader is backed up to the distributer and the sheaf discharge gate is opened.

DRAFT-COUPLING.—J. W. BULLER, Hillsboro, Kans. The principal objects of this invention are: to provide means for automatically releasing a movable drawn member from power means for arresting the former, and to prevent wrecking a plow when its progress is arrested independently of the tractor means during the progress.

Of General Interest

TENT AND HAMMOCK.—L. E. TRIMM, 677 E. 21st St., Brooklyn, N. Y. The invention has for an object the provision of a construction wherein the device may be used in its combined capacity as tent and hammock or may be used separately. Another object is to provide a tent and hammock arranged to be supported by ropes to suitable trees or supports, the arrangement being such that the hammock may be used as a bed in the tent or as a canopy or fly for the front of the tent.

RIFLE.—H. H. JONES, Holland, Ore. The principal object of the invention is to provide a simple yet highly efficient and durable rifle which will utilize the forms of expanding



CENTRAL LONGITUDINAL SECTIONS OF THE GUN, SHOWING A BULLET IN POSITION TO BE FIRED, AND BEING LIFTED FROM THE MAGAZINE

gases to drive the bullet from the barrel. A further object is to provide a gun in which the gasolene or other fuel used is mixed with air, and supplied to a combustion chamber at the breach of the gun, thus making it unnecessary to provide cartridge cases for the bullets to contain the explosive powder for impelling them.

PROCESS AND APPARATUS FOR METAL PLATING.—R. J. PIERSOL, Houston, Pa. The invention relates to a process for the plating of one metal with another metal which consists in enveloping the metal with the higher melting point by the fused bath of the metal with the lower melting point, said means being heated *in vacuo* to a temperature between their melting points. The device consists of a vacuum jar, a container placed in the jar adapted to contain a fused material, and means for lowering the second material into the first mentioned fused material.

DISPENSING CAN CLOSURE.—J. H. HOWARD, 2138 Perry St., Jacksonville, Fla. An object of the invention is to provide a device which when operated, opens the outlet of the can, causes a forceful ejection of a portion of the contents thereof and then closes the outlet. A further object is to provide a dispensing can closure which causes a uniform discharge at each operation and prevents wastage through careless operation.

SHELF.—F. GRAMMICH, 499 Vandervoort Ave., Brooklyn, N. Y. The invention relates to a sheet metal shelf so formed that comparatively thin sheet metal may be made to possess the necessary strength to sustain a considerable load. The object is accomplished by folding the sheet metal at one or more points in such manner that it will present members serving to stiffen the shelf as well as to give under support thereto.

HUMIDIFYING APPARATUS.—V. W. MCADAMS, 218 So. Clarkson Ave., Denver, Colo. An object of the invention is to maintain a desired degree of humidity in a show case, more especially intended for tobacco, cigars and cigarettes, or the like by automatically increasing the moisture on the one hand or supplying a drying heat on the other hand, the moisture supplying means and the drying means being governed by a hygroscopic controller.

PENCIL SHARPENER.—J. SONTHEIMER, R. No. 5, Lincoln, Neb. The general object of the invention is to provide a sharpening edge in a tubular member ground so that the sharpening edge is presented at the edge of the opening produced by the grinding, whereby the sharpener may be used in different ways for sharpening a pencil. The sharpener is embodied in a tubular pencil attachment having pocket clips so that it may always be ready for use simply by slipping the clip fitting from the pencil.

CLUSTER BACK FOR JEWELRY.—O. P. BAILER, cor. Main St. and Jefferson Ave., Memphis, Tenn. The invention relates more particularly to the cluster back used in setting cluster tops in various mountings. The principal object is to do away with use of a necessity for solder, thus reducing the cost of manufacture. Another object is to provide a cluster back which is interchangeable and can be quickly applied to or removed from any form of setting, and which will simulate the facets of a full gem.

Hardware and Tools

LOCK FOR METERS, ETC.—H. H. ROE, address Podlashue & Nicholson, 22 Bureau St., Pretoria, South Africa. The invention has for its object to provide locks for a number of special purposes, as for instance, water and gas meters, pressure gages, time recorders, handcuffs, motor car hoods, bicycles and the like; the construction is of few parts and easily operated. Another object is to provide a single key and single hand-operated member, with a manually actuated bolt held normally in locked position and a key operated screw.

VALVE FOR PNEUMATIC TOOLS.—W. S. WHYTE, 1128 W. 14th St., Bedford, Ind. This valve is adapted to be inserted in a hose or conduit to control the flow of compressed air or other motive fluid to a pneumatic drill or the like. Provision is made for the gradual admission of compressed air to the drill to effect a variance in the power stroke of the drill.

WRENCH.—L. DOONAR, Bend, Ore. This tool is specially designed for use in removing the nuts which hold the bearing caps on the connecting rods of an automobile engine and particularly for use in connection with number four piston of a Ford automobile which is known in the art to be particularly inaccessible.

ANTI-RATTLE CATCH.—C. J. HAGSTROM, Maple Ave., Glen Cove, N. Y. This catch is particularly adapted for use on doors, swinging windows and the like. The bolt of the catch is pivoted and is held in normal position by means of a spring. This makes the projecting end of the bolt bear against the socket piece in the jamb and prevents the door from rattling.

Heating and Lighting

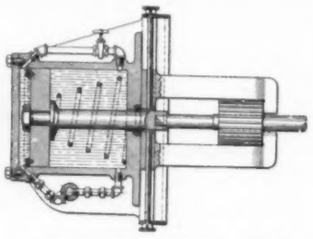
GAS HEATER.—C. M. MOGNI, 325 W. 4th St., New York, N. Y. The object of this invention is to provide a new and improved gas heater more especially designed for use in laundries and other establishments for heating sad-irons and like devices. The heater is arranged to produce an exceedingly intense flame to insure a quick, effective heating of the sad iron.

RADIATOR.—C. C. MANKER, Mayfair Apts., 40 St. James St., Los Angeles, Cal. Provision is made in this invention whereby oil or gas burners may be used in the ordinary steam radiators now in common use for producing a proper steam heat. Means actuated by the steam in the radiator control the volume of oil or gas fed to the heater, thereby producing automatically a uniform heat.

OIL BURNER.—C. C. MANKER, Mayfair Apts., 40 St. James St., Los Angeles, Cal. This oil burner may be applied to various uses, such as cook stoves, heating stoves, furnaces and the like. It dispenses with the use of an auxiliary pressure such as that supplied from compressed air, the arrangement being such that the pressure of the gasified fuel is sufficient to force the gas into the combustion chamber and at the same time to entrain a requisite quantity of air.

Machines and Mechanical Devices

HYDRAULIC GEAR JACK.—A. W. HILLIARD, R.R. No. 2, Wheelersburg, Ohio. An improved hydraulic jack is provided by this invention adapted to strip or remove a gear, pinion, cam, collar, commutator core, or various other devices from the shaft carrying



IMPROVED HYDRAULIC GEAR JACK

the same. The invention provides adjustable means for engaging and holding the gear or other device against longitudinal movement while the shaft is removed by hydraulic means.

WIRE-DRAWING MACHINE.—D. C. SULLIVAN, G. L. HAWKINS, and W. J. MACMILLAN, Address Almion Engineering and Contracting Co., 25 Church St., New York, N. Y. By means of this invention two wires may be simultaneously drawn with the same source of power. The construction is such as to allow of stopping the reduction and removing either of the wires without stopping the drawing or reducing operation of the other wire.

Medical Devices

TONGUE DEPRESSOR.—C. MACM. BUGBEE, Springfield, Vt. The invention comprehends a tongue depressor having such form that it may be made up inexpensively and be used for depressing the tongue under such conditions that a thorough inspection can be made at any and all stages of the use of the device.

Prime Movers and Their Accessories

VAPORIZER FOR HEAVY OILS.—C. C. MANKER, Mayfair Apmt., 40 St. James St., Los Angeles, Cal. The invention relates to vaporizers for heavy oils such as kerosene and the like, for use in connection with automobile engines or gas engines in general. An object is to provide a simple device by means of which the engine may be started on the low grade oils, thereby obviating the necessity of carrying additional fuel, such as gasoline, for starting purposes; the device also dispenses with the ordinary carbureter.

INTERNAL COMBUSTION ENGINE.—R. P. GRIEVE, 327 E. 22nd St., Brooklyn, N. Y. The invention pertains more particularly to a piston construction of an internal combustion engine. It is the object of the invention to improve the construction of pistons in two piston engines in such manner that one of the pistons is adapted to be protected by the other piston. It is a further object to construct a super-piston in such manner that its radiating surface is greatly increased contiguous to the walls of the cylinder in order that the same may be more effectively cooled.

VALVE SPRING LIFTER.—G. T. EUARD, c/o M. R. Deyo, Peoria, Ill. An object of the invention is to provide a device which is especially adapted for use in connection with the valves of internal combustion engines, such as are employed in automobiles, but may of course be adapted for various other valves. A further object is to provide means for lifting the pressure disk on the valve stem against the action of the valve spring, so as not to exert any angular or torsional strain on the parts.

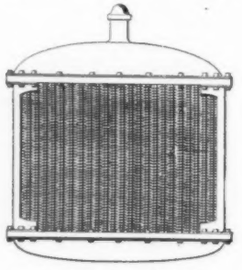
Railways and Their Accessories

SAFETY DEVICE FOR CATTLE AND RAILWAY CROSSINGS.—J. I. DOMINGUEZ, Calle Maipu 671, Buenos Aires, Argentina. The invention relates to a device for preventing cattle or animals from gaining access to the interior of tracks. The invention essentially consists of a plain grating provided with rotary rollers and so balanced in its conjoint that when an animal should step thereon a part of the device will descend and the animal will recede when noting that it has stepped on a false floor.

CATTLE GUARD.—J. I. DOMINGUEZ, Calle Maipu 671, Buenos Aires, Argentina. This invention relates to a device for preventing cattle or the like from entering the tracks of railways by the openings left at the level crossings. The device provides a grating so held in suspense that the same may shift or oscillate in any direction so as when simply stepping with the foot thereon it will cause the animal to lose equilibrium and getting frightened will withdraw therefrom.

Pertaining to Vehicles

AUTOMOBILE RADIATOR.—C. COSTELLOE and S. G. STOLL, 560 Morton Court, Hammond, Ind. An object of the invention is to provide an automobile radiator having as one of the prime features, the ability to easily remove



A FRONT ELEVATION

the top and bottom tanks so that the tubes may be readily reached for replacement and repair. Another object is to provide a radiator with means for simultaneously radiating the heat and adjustably checking the flow of the water.

RADIATOR SUPPORT.—A. L. W. OHMACHT, Cresco, Ia. An improvement is provided by this invention in supports for holding radiators in various positions so that any part of the radiator may be brought into position accessible for soldering and so that the hot solder will run into the desired place by gravity.

Designs

DESIGN FOR A TONE ARM.—M. BORRIS, 2992 W. 31st St., Coney Island, N. Y.

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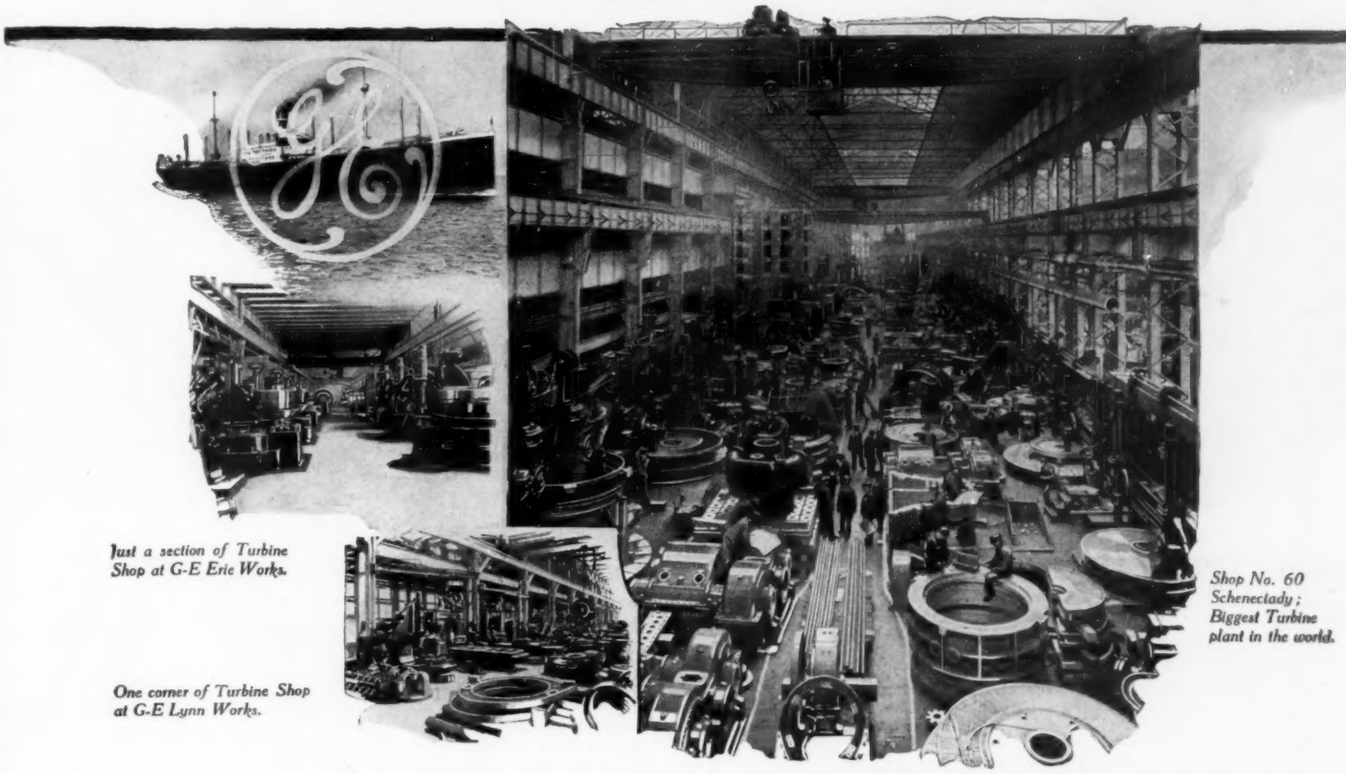

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Civil Engineering

(Continued from page 326)

who died in the war. The dimensions of this bridge are so great that it will be the largest single engineering work in steel ever built, or probably that ever will be built.

The suspension bridge, for structural reasons, is suitable for bridges of over 2,000 feet span, and for long-span bridges below 2,000 feet, the cantilever may be preferred. The two most notable examples of the cantilever are the two-track railway bridge over the Firth of Forth, whose two main spans measure 1,710 feet in the clear, and the Quebec Bridge across the St. Lawrence, with its main river span of 1,800 feet. Among the arch bridges, the longest single span is that built across the East River at Hell Gate, 1,017 feet between the abutments.

Tunnels and Subways

Conspicuous in the review of the past seventy-five years of civil engineering are the vast works of tunneling which have been carried through as part of the work of providing urban and suburban communication. A first fruit of electrical facilities was the construction of the two main-line tunnels beneath the North River and the construction of electrified terminal stations in the heart of New York for the Pennsylvania and the New York Central Railroad systems. Then four tunnels known as the "Hudson Tubes" were built below the North River to give direct rapid transit from New Jersey to Manhattan. Another vast work was the construction of subways in Greater New York, which today have a total of over 600 miles of track in operation with a system of express trains running well above 40 miles an hour. The rapidity of sub-aqueous construction has been due to the use of the shield with pneumatic pressure.

Foundation Work

The method of building deep foundations in loose and water-bearing material, contrary to the popular impression, has been long established. Smeaton, in 1778, sank the foundations for the bridge at Hexam, Northumberland, by the use of compressed air. As an alternative to that system we have the open cofferdam, a notable example of which was the construction by American engineers toward the close of the last century of the Hawkesbury Bridge in Australia. The closed caisson method has been invaluable in the construction of piers for bridges, and in the preparation of foundations for the modern skyscraper. Perhaps the most extensive use of the pneumatic caisson has occurred in this city, where the rock level is found at a depth of from a few feet to over 200 feet. With the introduction of the steel frame building the weight is concentrated at certain defined points over the area of the foundations and in building these, caissons are sunk to the solid rock and then filled with concrete to the appropriate level.

Water Supply

Previous to 1845, the United States could boast of no city water supply of any magnitude, but about that period, the city of New York built a dam in the Croton watershed some thirty to forty miles from the city, and constructed also the old Croton aqueduct which brought the water from Croton Dam to service reservoirs in Central Park. Some fifty years later it was realized that the supply must be largely increased, and in the early 90's, a new dam and new aqueduct were built, and the new and old aqueducts together delivered about 385,000,000 gallons daily to the city. So great was the rate of increase in population of Greater New York that it became necessary to go much farther afield and bring in the mountain water of the Catskills. By the construction of the Olive Bridge Dam across the valley of the Esopus, the Ashokan reservoir with a capacity of 132 billion gallons was formed. This dam is 220 feet in height, and the water is led to New York City by an aqueduct from 14 to 17 feet in diameter which extends for a distance of 90 miles and in a deep tunnel is carried through the rock at a depth below the streets of Manhattan from 300 to 750 feet. Another notable water supply is that of the city of Los Angeles. The water is brought for a distance of 254 miles, partly in canal and partly in tunnel, and the daily supply to Los Angeles is 250,000,000 gallons.

Of all the great irrigation projects, the largest is that of the United States Government for reclaiming desert lands between the Mississippi and the Pacific Coast.

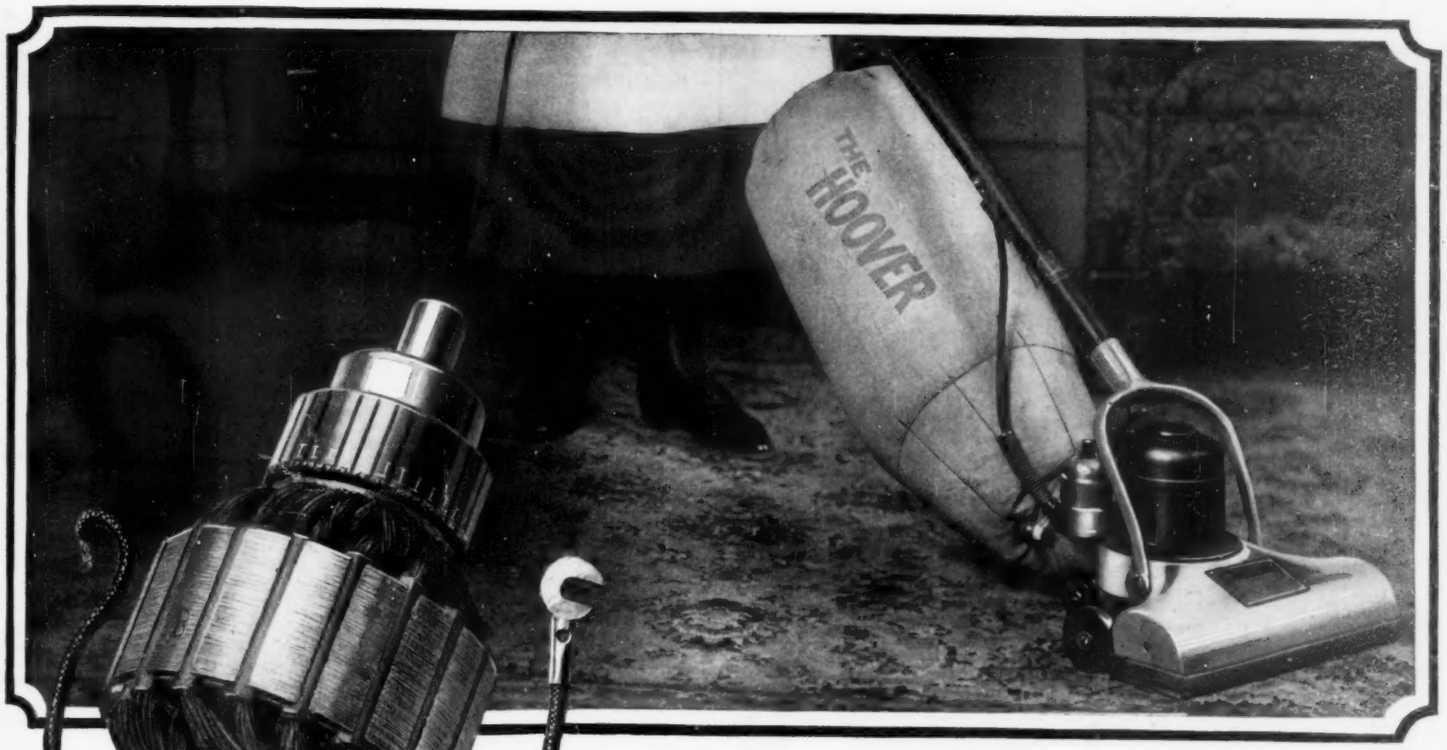
Among the many notable dams constructed for this work are the Roosevelt and the Shoshone dams, which are over 300 feet in height, and the Boise Canyon dam, 350 feet high. There are between 700 and 800 miles of canal, carrying from 300 to 800 cubic feet per second, and over 6,000 miles of smaller canals. Mention should be made here of another vast irrigation scheme made possible by the solid masonry of Aswan dam in Egypt, which extends for over a mile across the bed of the upper Nile River, and impounds 81,200,000 cubic feet of water.

Canal Construction

With the exception of road construction, the building of canals is the most ancient among the works of civil engineering, as witness the famous canals of Mesopotamia which rendered possible the flourishing civilization of the ancient races which dwelt in the valleys of the Tigris and the Euphrates. The greatest work of canal building in the United States during the past seventy-five years has been the continual enlargement and improvement of the Erie Canal connecting Lake Erie with the Hudson River by way of the Mohawk Valley. As opened in 1825, it had a maximum depth of only four feet; but improvements made between 1836 and 1862 involved the increasing of the depth to seven feet, and there has recently been completed a final reconstruction at a cost of over $150,000,000, which provides the canal with a minimum depth of twelve feet capable of taking barges of 1,000 tons.

Of the other notable canals built during the past seventy-five years are the Suez Canal connecting the Mediterranean with the Red Sea, which was completed by De Lesseps in 1869. Its original depth was 28 feet and subsequent work included the enlargement of the prism and the securing of a depth of 31 feet. The Kiel Canal between the mouth of the Elbe and the Baltic, a distance of sixty miles, was completed in 1895. There was completed by this country at the period of the opening of the great war the largest and most difficult work of canal construction in existence, namely the Panama Canal. It extends fifty miles from deep water to deep water, and it is remarkable for its great width and depth, the enormous amount of excavation involved and for the great difficulties encountered because of the climate and the unstable nature of the ground through which it was built. The problem of the turbulent Chagres River was solved by building a huge dam at Gatun and forming Gatun Lake with an area of 165 square miles. The dam is over 2,000 feet wide at its widest point. The depth of the canal is 45 feet. The locks have a width of 110 feet and a useable length of 1,000 feet.

The estimated cost of construction was greatly increased by the fact that what was supposed to be soft rock proved, on being cut and exposed to the water, to be a disintegrating material which flowed into the canal until it assumed a natural angle of repose of one to seven. The total cost is about $400,000,000.



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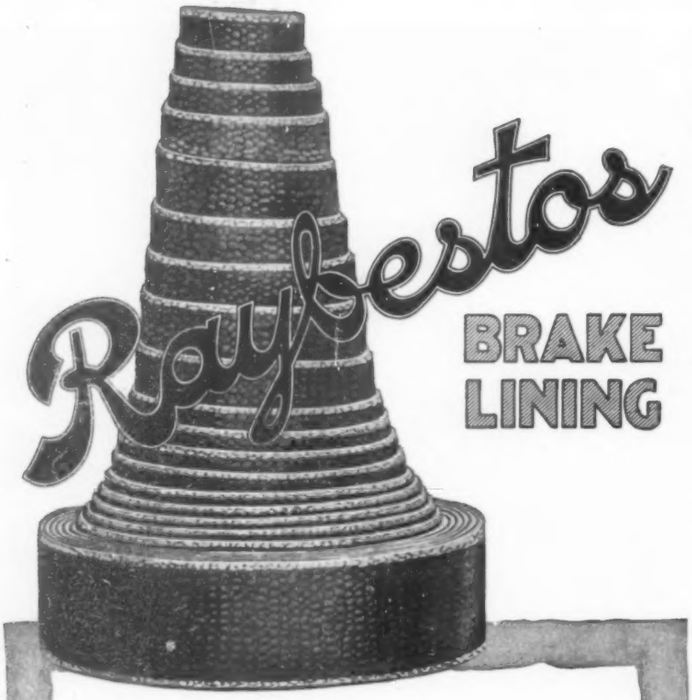

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Seventy-five Years' Growth of the Steam Railroad

(Continued from page 330)

railroad lines was equipped with block signals. In 1845, there was practically no block signalling in this country, and the Pennsylvania was the first road to make extensive use of the system, which it did in 1864. The Canadian Pacific adopted it in 1886, and thereafter it was gradually, but all too slowly applied to American railroads. Our great contribution to signalling was the introduction of the automatic signal, in which the train, by means of an electric circuit through the rails, operates its own signal and automatically safeguards itself. The first automatic signal was used in the universal track circuit installed on the Eastern railroad in Massachusetts, in 1871. Future development will be along the lines of what is known as the automatic stop, which consists in tying the signals in with the moving train so that if an engineer runs by a signal, the signal itself will automatically set the brakes and stop the train. A magnificent installation of this kind is that on the New York subway, where trains run at 40 miles under a headway of less than 1¾ minutes. So successful has this proved that something like a billion and a half passengers have been transported on the New York subways without the loss of a single life.

Growth of the Steam Locomotive

The development of the locomotive has kept pace with, if indeed it has not been in advance of, the development of roadbed and general equipment. A typical locomotive of seventy-five years ago was a wood-burning engine weighing about eighteen tons and using the universal, Stephenson link motion. The earliest locomotives of this country were generally imported or were built along English lines; but very early the American locomotive began to develop its own peculiar characteristics. The rigid plate frame with inside cylinders, almost universally adopted in England where the roadbed was of more solid construction, was not found suitable to the more lightly constructed tracks of early American days. These tracks called for a special type of locomotive, having lateral and vertical flexibility. The lateral adjustment was obtained by means of the leading truck, and the vertical adjustment by means of equalizing levers. The weight is thus carried upon three points of support, one forward beneath the cylinders, and one on each side of the firebox. By this arrangement, the shock of any one wheel passing an obstruction is distributed and reduced before it reaches the main body of the engine. This combination made it possible to maintain high speeds over a track which would have ditched an English engine.

An engine of 1845 would have cylinders 15 by 20 inches, a weight of 20 tons, and drivers 4½ to 5 feet in diameter. Steam pressure was from 90 to 120 pounds. In 1848, the Baldwin Works built an express engine with cylinders 17¼ by 20 inches, and a pair of 6½ feet drivers; but she was considerably ahead of her time. That was a day of much experimentation. Single drivers of a diameter up to eight feet, were to be seen in service. A ten-wheel engine with six-coupled drivers was turned out by the Rogers Locomotive Company as far back as 1848. In the decade 1850-60, the coal-burning locomotive became common, and wood as fuel was gradually abandoned. About this time there came into use the wagon-top boiler, and the effect of anthracite coal was shown in the celebrated "camel backs" of the Ross Winans. The next deade, 1860-70, witnessed the introduction of the "Consolidation," the Bissel truck, and the swing-bolster truck. In 1870-90 there was a continual increase in the weight and power of locomotives, and they became classified into distinct types according to the work for which they were designed.

The compound engine was introduced into America in 1888, when the Pennsylvania Railroad purchased an English three-cylinder compound engine for trial. It proved to be highly economical, but it did not have sufficient power to haul the heavy passenger trains of the company's service. Compounding has been thoroughly tried out in this country with variable results. Today the tendency is toward the use of superheated steam in simple engines of large cylinder capacity. As showing the state of development of the passenger locomotive in the last decade of the previous century, we mention No. 999 of the New York Central system. This four-coupled express with 19 by 24-inch cylinders, 86½-inch drivers, 1930 square feet of heating surface and 190 pounds of steam pressure, hauled a 641-ton train from New York to Buffalo, a distance of 436.32 miles, at the rate of 64.22 miles an hour, exclusive of stops.

The Era of High-Speed Travel

With the appearance of No. 999, there set in an era of high-speed passenger travel, which culminated in the first decade of the present century when the New York Central Railroad placed in service a train which made the trip from New York to Chicago in eighteen hours—a challenge which was promptly answered by the Pennsylvania Railroad. Since that time, in response to a demand for safety and for reasons of economy, the running time of these trains has been cut down, and it is not likely that any such speed schedules will be attempted in this country for many years to come, not at least until electrification has become general.

So far as locomotive design is concerned, the effort of the past two decades, and especially of the last ten years, has been to increase power so as to increase the capacity of the trains whether in freight or passenger service. The standard, heavy, express passenger locomotive of today has six coupled-drivers with a leading four-wheel truck and a pair of trailers beneath the cab; and the most powerful of these wonderful machines is capable of hauling a twelve to fourteen-car Pullman train weighing from 900 to 1,000 tons at the rate of sixty miles an hour on level tracks. An even greater increase in size and power has taken place in the freight locomotive, and we illustrate a well-known locomotive, the "Virginian," which was built by the American Locomotive Company for service on a stretch of fourteen miles of track which has a ruling grade of 2.07 per cent. This engine, the most powerful steam locomotive in existence has cylinders 30-inch diameter high pressure and 48-inch diameter low pressure by 32-inch stroke. The boiler has an internal diameter of 8 feet 7¼ inches. The total heating surface, including superheater, is 10,725 square feet, and the tractive power when the engine is working the compound is 147,200 pounds; when working simple, it is 176,600 pounds.

Introduction of Electric Traction

It was inevitable, in view of the success of the electric trolley, that electric traction should be applied to steam railroads. The first installation was for hauling trains through the belt line tunnel of the Baltimore & Ohio Railroad at Baltimore. This was followed by the very ambitious electrification of the terminal lines of the New York Central and the New York, New Haven and Hartford Railroads in New York City. This terminal zone, as it is called, extends 30 miles out on the main line of the New York Central to Croton, and some 75 miles to New Haven on the New Haven line. In the interval since that great work was decided upon, improvements in the art of electric traction have been such that it is now possible to utilize the direct-current system economically over continuous stretches of

(Continued on page 354)

Mo-lyb-den-um Steel

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THROUGH the ages, man's progress in the development of transportation has been dependent upon the discovery of better materials with which to put his ideas into execution.

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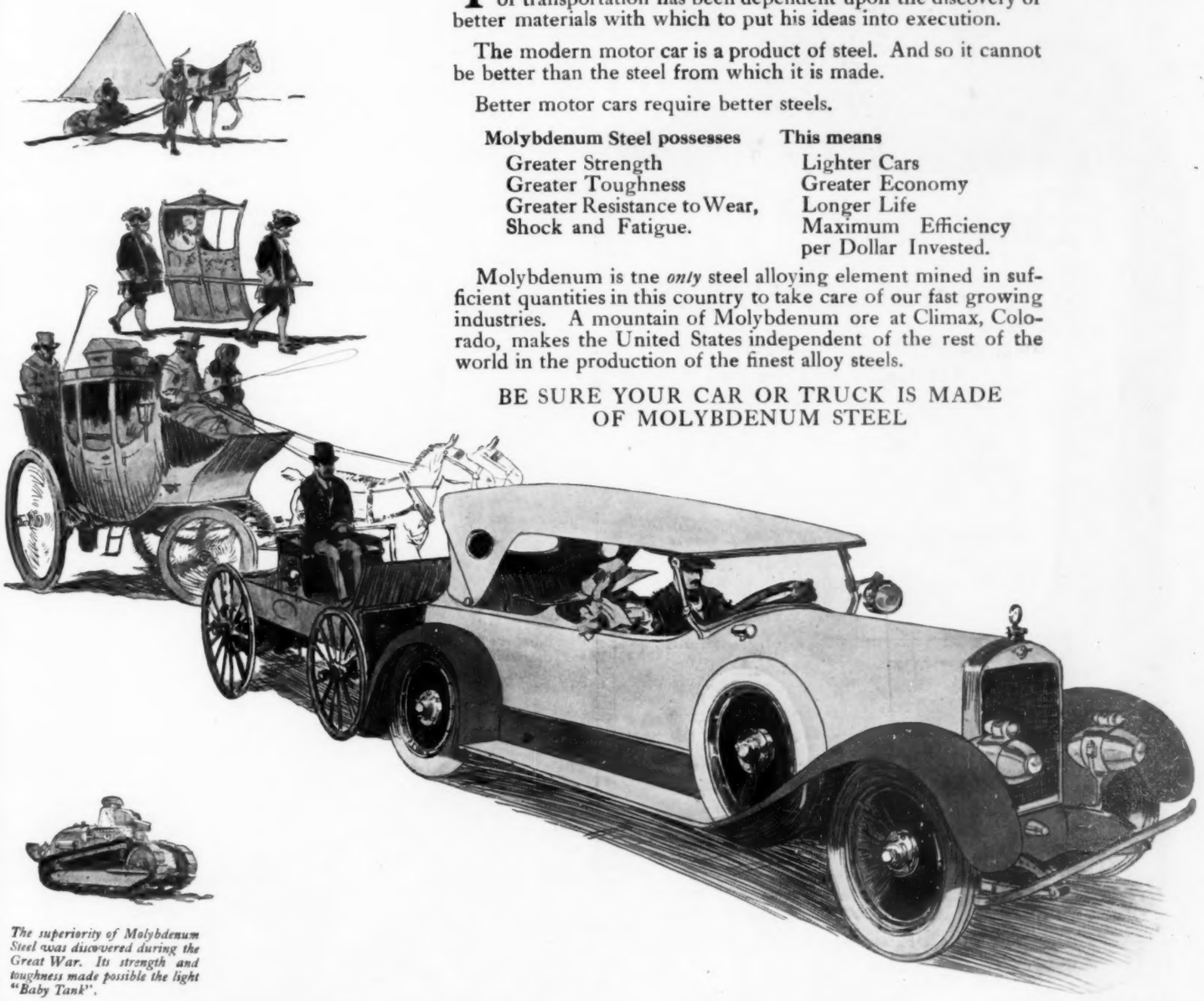

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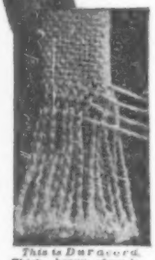
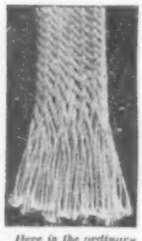
Duracord can be furnished in all sizes of portable electric cord and also in the larger sizes of single and duplex cable. Ask your electrical jobber about Duracord or let us send you samples of Duracord and ordinary cord for you to test and compare yourself.



This is Duracord. Thick, heavy strands, woven like a piece of fire hose, not braided. Picture shows outside covering only with impregnating compound removed.



Here is the ordinary braided cable covering. Note the open and porous construction, easily cut, shredded or unraveled. Compare it with the illustration of Duracord above.

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Seventy-five Years' Growth of the Steam Railroad

(Continued from page 352)

line, that could not have been economically operated ten to fifteen years before. The most famous installation is that made by the Chicago, Milwaukee and St. Paul Railroad for the operation of its mountain division; and for this purpose several exceedingly powerful passenger locomotives exceeding in their hauling power any previous locomotive, whether steam or electric, are in operation on that division. We illustrate one of these which has an over all length of about ninety feet. There are twelve 68-inch drivers, driven through gears by six electric motors, which develop a total of 4,200 horsepower for one hour and a normal starting drawbar pull of 100,000 pounds. The total weight of the locomotive is 275 tons, and it is capable of hauling the heaviest all-steel Pullman trains at a speed of 30 miles an hour on the steep mountain grades. It now seems to be only a question of time when we shall see a practically universal application of electric traction on the railroad systems of the United States. Based on data gathered by the Chicago, Milwaukee and St. Paul Railroad from its electrified mountain division, the fuel economy resulting from electric traction would represent a saving, annually in coal consumption of 122,500,000 tons of coal—that is to say, over two-thirds of the coal burned in the steam engines of our railroad system would have been saved during the year 1918, had the railways been completely electrified along the lines which today have been fully tried out and proved to be successful.

Seventy-Five Years of Applied Electricity

(Continued from page 333)

his laboratory grounds were illuminated by seven hundred lamps, took place late in December, 1879, and attracted prominent visitors from all over the country.

Development during the years 1880 to 1889 was rapid and important. Lamp costs were brought down, as simplified methods of manufacture were introduced. The price of arc light carbons was gradually reduced from $240 per thousand to about $10 per thousand. The art of "pasting" carbon filaments to the lead wires was discovered; previously, the filaments had to be attached by expensive mechanical devices, such as tiny bolts, nuts, washers, sleeves and clamps.

By 1890 electric lighting was beginning to be common in every civilized country. In 1891 the cellulose or "squirt" process of making carbon filaments was commercially introduced. Two years later the cellulose filament generally supplanted the carbonized bamboo. In 1895 came the "chemical exhaust" for incandescent lamps, which improved their average quality, at the same time reducing their cost. Indeed, the cost was reduced from 32½ to 20 cents each by 1895.

In 1892 the substitution of molded bulbs for "free-blown" bulbs proved another step forward. Phelps, in 1898, invented the turn-down lamp. In 1898 Dr. Welsbach, of gas-mantle fame, produced his first osmium filament lamp, although metallic filaments came into general use many years later. The mercury arc lamp was originated by Arons in 1892, and later developed to a point of greater commercial practicality by Cooper Hewitt.

The invention of the enclosed arc lamp in a practical form was announced at an electrical convention in 1894, when L. B. Marks described the first enclosed arc lamp embodying the points that made it, for a period of ten years, the favorite unit for high candle-power lighting in America. In 1899 the Bremer flame arc was announced, and in the following year Bremer exhibited at the Paris Exposition a model having four impregnated carbons, so arranged that the light produced was thrown downwards. Other forms of luminous arcs followed, with various combinations of salts for producing various kinds of light.

The discovery of ductile tantalum came from a German laboratory in 1901, and the first experimentally successful tantalum lamp was constructed a year later, although several years more had to elapse before this form of lamp was ready for commercial exploitation.

In 1905 the "metallized" carbon lamp, in connection with which notable work was done by J. W. Howell, made its appearance and served as a sort of stepping-stone to the lamps of still higher efficiency that were about to make their appearance.

In 1907 came the pressed-filament tungsten lamp, for which we are indebted in great measure to two European inventors, Just and Hanaman. This lamp, in the hands of such men as Dr. W. D. Coolidge, Dr. A. Pacz, and a host of other experts, has gradually evolved into a strong, durable, cheap, drawn-wire lamp.

Within the past few years the gas-filled tungsten lamp has come to replace the vacuum lamp of the recent past. Indeed, at first these gas-filled lamps, generally using nitrogen, and in some instances argon, were available only in candlepowers running in the hundreds and even thousands. But during the past year or two the gas-filled lamp has been developed so that it is available in sizes as low as 50 watts, thus making it an all-round lamp.

From Morse's Telegraph to Bell's Telephone

That historic telegraph message, "What hath God wrought!" sent in dot and dash over a telegraph line from the Capitol, at Washington, to Mount Claire Depot, in Baltimore, dates back to May 24th, 1844, one year before the initial appearance of the SCIENTIFIC AMERICAN. The message was indited by Miss Ellsworth, the daughter of the then Commissioner of Patents, and was intended to express the wonder of the achievement of the telegraph.

It was Samuel F. B. Morse who gave us the telegraph. As in the case of many other electrical machines and devices, we find many experimenters and investigators at work on the idea of communicating over wires by means of electric currents long before Morse's successful attempt; but the fact remains that Morse, like Marconi more than fifty years later, had to assemble numerous ideas together and work out the successful commercial telegraph. Hence Morse is the inventor of the telegraph.

Morse's original telegraph provided a pendulum carrying a pencil or marking device in constant contact wth a strip of paper that was drawn beneath the point by a gravity-operated movement. As long as no current came over the line, this arrangement would make a straight line upon the paper. The pendulum carried also an armature, and the electro-magnet was placed near the armature. A current passed through the electro-magnet would draw the pendulum to one side. On being released the pendulum would return, and in this way any amount of zigzag marks could be made on the paper as it traveled with the pencil constantly pressing upon it. Vail, an associate of Morse, made some changes in this device and substituted for the pendulum and marking pencil the familiar lever with pencil of a more recent type of Morse register, and substituted for the zigzag line the dot and dash system of telegraphy.

The telegraph is one device which has become simpler through perfection. As Morse conceived it, the telegraph was formidably complicated. For one thing, Morse wanted a recording device; he did not realize that men could be trained to read the signals by sound. Then he had trouble finding some suitable method of making the dot and dash signals at the sending end. For this purpose he used metallic type with indented faces so shaped as to open and close the circuit at

(Continued on page 356)

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Seventy-Five Years of Applied Electricity

(*Continued from page 354*)

proper times and for proper periods. Each letter constituted a separate type, which was mounted on a portrule. When this was filled with type representing the message, it was drawn under the contact point. Then, as a simplification of this, two contact points close together were used, between which a wedge was thrust by hand so as to open and close the circuit. Again, a keyboard like a piano, with each key for one given character, was tried out and abandoned. But by 1844 Morse introduced the plain key very similar to that in general use today.

By 1855 the telegraph had become a commercial proposition of no mean proportions. A straggling web of lines under the control of thirty or forty rival companies worked with different apparatus under different patents, covering the most populous area of the country.

Little had been done in the way of improvement. Indeed, the telegraph seemed about as efficient as could be wished for in view of the traffic requirements of those days. Operators here and there had begun to read signals by the sound of the marking lever. Morse was violently opposed to this practice, and insisted on the use of the tape. However, his collaborator, Vail, finally yielded to the operators' new method of reading signals, and by the simple suppression of parts, the well-known sounder came into being.

Some fifteen years later telegraph advanced still another step, namely, the duplex telegraph, enabling two messages to be transmitted at one time in either direction. The chief workers in this field were Gintl, Frischen, Siemens and Halske, Preece, Farmer, Nystrom, Maron, Winter, Stearns, and Muirhead.

Next came the quadruplex telegraph, with four messages sent simultaneously over one line. This seems to have been first proposed by Stark of Vienna in 1855, and subsequently worked at by Bosscha, Kramer, Mason, Schaak, and others. But the first to obtain satisfactory results was Edison, who invented his method in 1874.

From the land the telegraph passed to submarine cables, and many new problems arose which had first to be solved before commercial success became possible. The credit for having completely overcome these difficulties is mainly due to Dr. Muirhead of London. The experiments on short lengths in the English Channel and elsewhere fascinated American and British business men with the idea of a transatlantic cable, and it remained for Cyrus W. Field, who possessed unbounded persistence in his work, to lay the first transatlantic cable in 1866. With the aid of the "Great Eastern" a submarine cable was laid between Valencia, Ireland, and Trinity Bay, Newfoundland, in less than a month's time. The service was subsequently interrupted and repaired, but that is a matter of general history and of common knowledge.

The long cable brought out the fact that more sensitive instruments were required. Thomson, later Lord Kelvin, overcame the difficulty by inventing the mirror galvanoscopic receiver and later his siphon recorder. Other improvements followed.

Printing telegraphs, such as the stock quotation tickers, and high-speed telegraphs figure throughout the career of the telegraph, but space does not allow of touching upon these phases.

Like the telegraph, the telephone was suggested by various experimenters in an indefinite sort of a way, but it remained for the genius of Alexander Graham Bell to give the world the commercial telephone system. For instance, in 1861 Philip Reis of Friedrichsdorf disclosed in a lecture an instrument which he called a telephone, for the production at a distance of music and human speech. Perhaps Reis's telephone never talked, but it did transmit musical sounds. It was not until 1876 that Bell produced the first telephone which could transmit speech. Bell's patent has been called "the most valuable single patent ever issued." The early development of Bell's telephone was also due to Edison, Gray, Dolbear, Berliner, Blake, Hughes, and others. In 1877 Berliner invented the loose-contact transmitter and applied the induction coil between transmitter and receiver. These two inventions have been retained to this day.

Such men as Carty, Scribner, and Dean have brought the telephone to its present perfection. The one man who did most to create the switchboard is Charles E. Scribner. Prof. M. I. Pupin invented the loading coil in 1899, in order to obviate the bad effects of capacity on long-distance lines by increasing the self-induction. His invention made long-distance telephony practicable.

Within recent times we have the automatic telephone, which now threatens to supplant the usual manually-operated system because of the increasing difficulties in the way of maintaining a large personnel.

Another phase of communication is the telautograph, but so involved is the development of this method from the early efforts to the present perfected systems that nothing further can be said here. The same applies to the various systems of transmitting photographs and drawings over wires.

Marconi's Contribution to Communication

Again it is the old story of numerous attempts culminating in the work of one man capable of developing a commercially promising system; this time Marconi's story—and wireless. We must necessarily skip over the efforts of Hertz, Branly, Popoff, Lodge, and others and come right down to 1895 when Marconi, as a young man, was conducting experiments on his father's estate at Bologna, Italy. From a few hundred feet separating his transmitting and receiving equipments, Marconi soon increased the distance to over a mile. The apparatus was constantly being developed, and larger aerials and more power were being employed at the transmitting end. The distance covered rose to 100 miles, several hundred miles, and finally Marconi was ready for a transatlantic attempt. On December 12th, 1901, Marconi succeeded in transmitting repetitions of the letter "S" across the Atlantic from Poldhu, in Cornwall, to St. John's, Newfoundland.

Marconi was by no means alone in the development of wireless communication. In fact, many valuable contributions to the art came from many other inventors, and it is well to mention Fessenden, Fleming, Shoemaker, Lee de Forest, Braun, Poulsen, Ferrie and Wein. Wireless rapidly developed, and late in 1907 Marconi opened a restricted public radio service between Glace Bay, Nova Scotia, and Clifden, Ireland, thus going into direct commercial competition with the Canadian cables for the first time. Less than a year later the Glace Bay service was offered to all classes of telegraph traffic.

Since the war wireless has met with a remarkable development, due in large measure to the urgent necessity for all possible methods of communication. The transatlantic stations at Tuckerton, N. J., and Hanover, Germany, were put into communication as early as 1914, using the ingenious system of Goldschmidt. During the period of the war we find more and more wireless systems turning to the vacuum tube for receiving, amplifying, modulating and transmitting purposes. Indeed, this simple device—little more than an incandescent lamp with additional electrodes inserted in the vacuum—may be said to have solved practical wireless telegraphy and wireless telephony. Originally suggested by Edison's experiments, introduced in wireless communication by

(*Continued on page 358*)

Fig. 1

Lower costs attained by elimination of unnecessary machining

NO detail of machine-shop work holds the eye of the inexperienced visitor more absorbingly than the spectacle of a machine as it gouges off deep bites of metal from a casting. Compute the cost of the machinist's time, lump in the proper overhead for the machine and floor-space, and then add the cost of waste metal and it becomes quickly apparent how expensive a form of entertainment this can be.

Every unnecessary cut is pure waste.

It represents a mistake in the selection of castings.

On this page are shown in photograph and diagram exact reproductions of castings taken from actual practice which illustrates the waste resulting from inferior castings.

The upper row in the photographic illustration above (see Fig. 1) shows a series of castings produced by machine moulding. Below is the same casting in series as made from hand-made moulds. Even in reduced reproduction the contrast between the non-uniform hand-made casting and the uniformly regular machine-made casting is easily apparent. (No effort was made to make a favorable selection of the machine-made castings.)

As the lower group of castings came to the machine shop for layout, each casting was a separate problem to the layout man. He was compelled to locate holes off center on bosses—and do many other undesirable things to make his principal cuts come uniform—or at all. Contrast this with the upper group of castings—"as like as peas in a pod"—the layout man's difficulties disappeared — repetition makes fast work easy.

Furthermore, in the case of the hand-made casting the shell of pad metal not only bulks greater but its thickness varies greatly. So great is this variation that frequently such castings, although they appear to the eye as O. K., are dangerously near being defective because there is no margin of metal between the surface of the rough casting and the specified dimension of the finished surface. When "hollows" penetrate even $\frac{1}{32}$" too deep, no choice then remains except to scrap the casting and charge to "Expense" the labor performed on it before the discovery.

The irregularity of the hand-made casting, when compared with the even, uniformly shallow depth of waste metal on the machine-moulded casting, makes clear at a glance the greater rapidity and uniformity possible in machining the latter.

Machine-moulding in the best machines can be accurately controlled within $\frac{1}{16}$ inch per inch of pattern draw. This degree of accuracy, backed by the fact that the machine-made mould is free from non-porous spots caused by hand-patching and slicking, insures the remarkable uniformity here pictured.

Based on this uniformity (and impossible without it), wholesale economies can be effected in machine-shop practice where large scale production is the goal. *First* comes the sweeping economy in layout time where one laying-out of a job serves as the only basis required for repetition day after day of the same cuts on castings which are themselves uniform. *Second* comes the saving in cutting time, due to reducing the shell of waste metal to a minimum. Compute the saving of only a single cut less across each face of a casting and then multiply it by the number of castings handled per day and you gain a partial

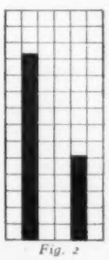

Fig. 2

Figure shows an average of comparative costs furnished by scores of machine shops before and after the adoption of machine-made castings.

picture of the resulting yearly economy. The *third* economy results from the closely-held accuracy of the machine-made casting which virtually eliminates defective castings, and cancels the previous losses due to waste machining on defective castings—a decrease of 71% in defectives is the average result of the change to machine-made castings.

The sum of all these economies is graphically illustrated in Figure 2 which shows how the machining costs dropped in a large group of shops which adopted the machine-made casting.

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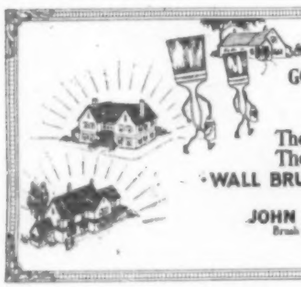

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New STROMBERG Does it!
CARBURETOR

Seventy-Five Years of Applied Electricity

(*Continued from page 356*)

Fleming, and developed to a high state of perfection by Dr. Lee de Forest, the vacuum tube constitutes the greatest step forward in the art since Marconi's first experiments. The vacuum tube, in its multitudinous sizes and designs, permits doing things hitherto deemed impossible.

The wireless telephone is a natural growth of the wireless telegraph. At first the electric arc was employed as the generator of high-frequency currents for radio-telephone purposes; but with the development of the vacuum tube the arc has lost its place in radio telephony except when it is a question of tremendous power. Even then, there are high frequency alternators, such as the marvellous machine of Alexanderson, which lend themselves to radio telephony. Such names as Poulsen, Fessenden, Colin, Jeance, de Forest, Arco and Majorana figure in the development of the radio telephone.

Nineteen hundred and twenty—and we have attained what appears to be perfection in wireless communication. We have numerous stations capable of transmitting and receiving signals over thousands of miles. The atmospheric disturbances have been largely ameliorated, and even now there are certain anti-static systems which promise to render wireless systems as immune from such disturbances as the underground telephone cable. It is a great step, to be sure, from Marconi's crude set of 1895 to the 12,500-mile Lafayette radio station at Bordeaux, France, constructed by the United States Navy during the war so that we might never be out of touch with our men "over there."

The Rise of the Automobile

(*Continued from page 335*)

still run by single-cylindered engines; the Haynes-Apperson, Winton, Stearns, Oldsmobile, Stevens-Duryea, Arrow and Peerless employed two cylinders; the Gasmobile boasted one of the earliest fours. For the next year the Locomobile came on the market in two- and four-cylinder models and the Franklin appeared as a four, while the Peerless added a four to its line; current opinion would doubtless have named two cylinders as standard practice for the ordinary car, and four as desirable in the big fellows. By 1905 the four-cylinder standard was well established. In 1907 the first six-cylinder model appeared in England, the work of Napier, and the precedent was quickly followed, until by, say, 1910, it might have been said that the two-cylinder car of 1902 had become a four, and the four a six. At the same time Hewitt produced an eight, but this precedent was ignored for nearly a decade; the earliest of the existing eights appears to be the Cadillac, of 1914. The tendency toward sixes, and later eights, continued; and finally, in 1915, the Packard, almost the last car to give up the single cylinder, was the first to set the mark at twelve.

A change of importance that ought to be mentioned is that from chain drive, universal in the early models, to the propeller shaft with bevel gears. If a date were to be set at which this became first effective, it would be somewhere in the vicinity of 1905.

The early designers surrounded the single cylinder with a water jacket, but made no definite provision for water economy. Perhaps they did not expect their cars to run far enough, on one stretch, to require fresh water. But by 1900 the cruising radius had gone up, and radiators recognizable as such made their appearance, though as late as 1902 they were universally low with sloping fronts. The higher, vertically up-standing type appeared in 1904-05, and swept the field clean within two years at the most. Circulation was by pump, until the Renault designers incorporated the thermo-siphon, which spread to a few other models after 1907. But it must be emphasized that air-cooling is not a recent development; the Franklin, which would be the Wilkinson if named after its creator, dates back continuously to 1902-03, and the Knox and Marmon, among others, were air-cooled for a time.

The dividing line between horseless carriage and automobile may perhaps be drawn from the point where the motor was transferred to the front and the conservative upright steering post with horizontal rod replaced by the more sporty wheel. Among the names that lived, the Knox, Duryea, Haynes, Oldsmobile, Stearns and Pierce were all handled through rods in 1902; the vogue of the wheel appears to have become definitely established not earlier than 1904. And Levassor's example in putting the engine where it belongs was still defied in 1902 by the Stearns, Pierce, Packard, Oldsmobile and others, but had become universal two years later. So perhaps we might say that the period before 1900 was that of the horseless carriage, and that after four years of transition we come to the automobile.

A Problem in Prosperity

It seems amusing to us, today, to turn back to 1910-12 and read that the vast increase in the use of the automobile had caused such a demand for gasoline that the quality had gone down to a point that constituted a problem. We will understand this better if we realize that the cars of 1900 and 1905, burning the high-grade gasoline then on the market, were expected to start, under all conditions and without priming, on a half or even a quarter turn of the crank. When the fuel became of such sort that this was not feasible, there was a universal consensus that some sort of starting motor would have to be devised. A great many sorts were put forward, but those that worked pneumatically or through springs or by introducing a preliminary charge of acetylene or some other violent explosive and touching it off with the spark went overboard when it was shown clearly that a wet battery could be built that would not be damaged by such roughing as it would get from riding in a car, and that a generator could be installed that would keep it charged to the necessary voltage for starting. The development of the electric starter began in 1910, and by 1913 was complete, all the better cars being by that time so equipped. But if a battery must be carried for this purpose, economy demands that it be used also for lighting and ignition, relieving the car of weight and installation expense represented by oil lamps and magneto. So we find at this time the very general reversion to battery ignition, referred to above. The magneto, however, has not submitted tamely to this. Admitting that at the slow engine-speeds of cranking, whether manually or by motor, the battery gives a better spark than the magneto, the advocates of the latter point out that its spark increases in intensity with engine speed and that it ought therefore to be better after the car gets under way. Opinion here is still in a point of flux; and it is difficult to say whether the present vogue of dual ignition represents really an effort to get the best of both systems, or merely a desire to sidestep the question of choosing between them.

From Sport to Utility

In the beginning automobile design and operation was a recreation, a means of riding a hobby and at the same time gratifying the mechanical instinct that impels men to play with motor boats and wireless and such things. A man built a horseless carriage and drove it about the roads of his home town, not so much from the desire to achieve transportation

(*Continued on page 360*)

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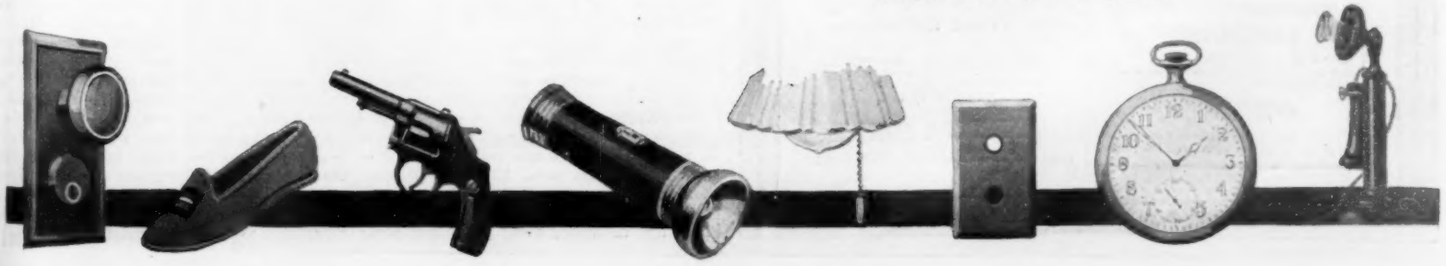

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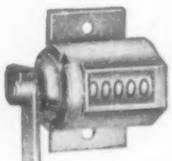

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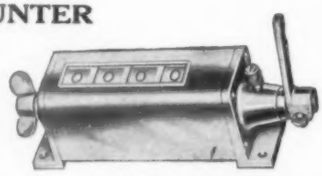

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SONNEBORN

The Rise of the Automobile

(*Continued from page 358*)

as to satisfy the inventive impulse in a wide-open field. When the experience of the pioneers had crystallized to a point which gave the driver of such a vehicle a sporting chance of getting it home again the same day, a market appeared for its sale to men who were willing to drive it but unable or unwilling to build it. On this basis the new industry had its beginnings; men like Haynes and Duryea and Olds in America, Panhard and Levassor in France, found that they could sell their machines to others, and immediately made it their business to do so.

The end of this experimental period might be set somewhere around 1899. It was here that the name "automobile" began to drift in from France, while self-propelled vehicles were seen in our streets with sufficient frequency to make it worth the small boy's while to coin the standard jibe, "Get a horse!" with which to greet them. The decade from 1898 to 1908, perhaps a bit shortened at each end, might fairly be called that of the automobile's adolescence—the period during which, like adolescent humans, it was always on the *qui vive* to show what it could do. In real, practical utility there was little advance over the preceding five years; but the automobile was so much faster and so much more reliable that real racing, on road and on track, was now profitable, and became characteristic of the epoch.

With due allowance for the extremes to which it was carried, this was a necessary stage in automotive developments, and one which led swiftly and surely to better machines. For if the race is to the fastest, it is equally to the contestant who is able to keep going. And when its racing performance had sufficiently demonstrated the automobile's ability to keep going, there were plenty of hard-headed gentlemen of finance to inquire whether there was not something useful that could be done with it. In answering this question in the affirmative the automobile industry passed into its third and present stage, that of wide commercial development as a recognized utility.

With the quest of utility, however, the designer must fact a brand new problem—that of building cars of diverse types for diverse special purposes. One angle of this problem is seen in the divergence of passenger cars. This multiplicity of types is a feature of the present-day automobile whose relative newness often escapes us.

Another thing that happens when the designer begins to consider the purpose for which his product will be used is the great divide between car and truck. So far as any published figures show, the first machines built in the United States for strictly and admittedly commercial use and under a separate classification were of date 1904. The beginning was small enough, only 411 trucks for the year; but these were really trucks, with frames and axles built for heavy loads and with power plant and transmission designed for the peculiar demands of hauling merchandise.

Truck and Tractor

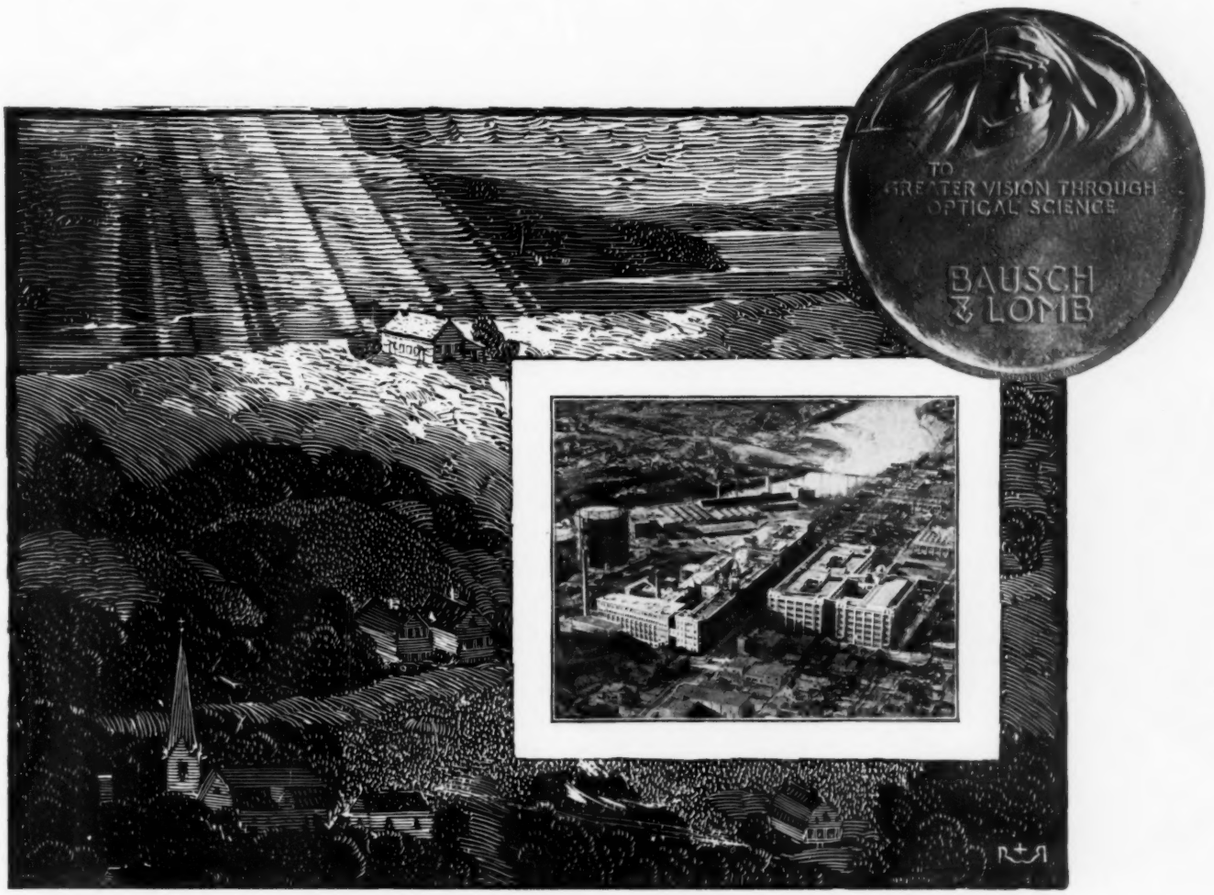
The trend of truck development is too technical to follow in detail, but we may note the major points of departure from passenger cars. The tendency in trucks is of course always toward greater load capacities, and toward ruggedness rather than refinement of detail. A significant divergence from passenger car history is shown in the development of the engine, which has met the additional demands from year to year by an increase in the size rather than in the number of the cylinders. The final drive has remained a much more open question than in the case of passenger cars. There are at least four fundamentally distinct systems still in vogue, including the chain drive so long ago discarded from passenger cars; and in addition the four-wheel-drive principle invented in the earliest days of truck manufacture continues in use by some makers, and offers another distinctive truck feature.

A little brother—sometimes, indeed, a pretty big brother—of the truck must be mentioned in the tractor. This is inherently a truck, with some means provided for taking better hold of the ground than is afforded by the ordinary tired wheels, so that it shall pull effectively when hitched to heavy agricultural machinery in the field. Wide rollers in place of ordinary wheels were the obvious first step; later these were provided with projecting plates and spikes of various sorts; finally the war, with its reinvention of the crawling, track-laying principle, gave the tractor manufacturer his biggest grip on the situation. Trucks of course have been used for hauling agricultural machinery since they first came out, just as there has always been more or less commercial use of passenger cars for light delivery work; but the tractor as an independent member of the automotive family might be dated back to 1912, with due recognition of earlier efforts.

The Automobile in 1920

The present survey may well be concluded with a word about the position held today in the world's economy by the automotive industries. It is in a way hardly necessary to dilate upon this, yet one or two concrete statements may help to a true realization of the vital importance of the automobile to our way of doing things. For one thing, we are told that while all the railroads of the United States in the course of a year yield about 45 billion passenger-miles, the automobiles of the entire nation are responsible for 70 billion of these units of transportation. Again, with the 3,700 passenger cars manufactured in 1899, the first year for which records exist, and with the 411 trucks of 1904, we may compare the present normal production of some two million passenger cars and three hundred thousand, plus, trucks. Finally, we have the fact that there are something like seven million automotive vehicles of all sorts in operation in this country today. Figures are given for the United States for the very simple reason that, alike in manufacture and use, this is the land of the automobile.

Under the head of general remarks about the rôle of the automobile in twentieth century economy the difficulty is wholly that of finding a brief statement that shall do the subject justice. In every single thing that we do today the automobile or the truck or the tractor occupies a position of importance. Perhaps the most illuminating statement that could be made would have to do with the manner in which all distances up to fifty, seventy-five, or even a hundred miles are made to vanish into nothing by the magic influence of the motor. The isolation of farm life is a thing of the past, for the farmer cannot possibly be more than an hour from a town that gives him access to high-class schools and stores and amusements. City congestion, serious as it is, would be vastly worse were it not for the manner in which the automobile extends the suburbs and the area of food supply far beyond the remotest possibilities of twenty years ago. Trucks carry freight from New York to Philadelphia in less time than it would take to get it to the freight yards and loaded on a train. In a word, the automobile—taking this term to include all gasoline-driven vehicles—is with little question the greatest ameliorating influence in modern life. And all this is an invention, not of the past 75 years, even though for its ultimate beginnings we have to go back almost to that time; but, as regards the time which has elapsed from the first really promising attack upon the major problems involved, a development of thirty-five years at the most.



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The Mastery of the Skies

(Continued from page 339)

The SCIENTIFIC AMERICAN during its seventy-five years of existence has chronicled the numerous and divers attempts at dirigible construction and travel. Thus in 1852 it chronicled the attempt of the Frenchman Giffard, who constructed a spindle-shaped balloon 143 feet long by 39 feet in diameter, and driven by a three-horse-power steam engine actuating a 11-foot screw. This dirigible voyaged from Paris at a sustained speed of six miles per hour through the air and with good control. In 1872 the German, Haenlein, with a cucumber-shaped coal gas balloon 164 feet long and 30 feet in diameter, driven by a gas engine taking fuel from the envelope, and actuating a single screw, attained a speed of ten miles per hour. In 1884 Renard and Krebs, in a torpedo-shaped dirigible 165 feet long and 27.5 feet in major diameter, driven by an electric battery motor, actuating a screw propeller, made the first return voyage against a moderate wind. The vessel showed excellent control, attained an average speed of 14.5 miles an hour, and was of model workmanship; but for lack of power it was practically abandoned till the advent of the automobile engine.

In 1898 Santos-Dumont, emulating the German Wölfert, who in 1880 first attempted to drive a dirigible with a benzine motor, sailed aloft in a spindle-shaped balloon 82 feet long by 11 feet in diameter, driven by a motorcycle engine of 3½ horse-power, carried in a car suspended beneath the envelope. Finding this vessel manageable and swift enough to make his clothes flutter, and amply rigid when its ballonet was properly inflated, he in subsequent years built fifteen more dirigibles of various designs.

Came 1900 and Count Zeppelin's début as an airship constructor. Emulating the Austrian, Schwartz, who in 1879 first tentatively drove a rigid metal balloon with a petrol motor, Zeppelin launched the first of his huge rigid dirigibles. Its hull, which was framed of aluminum and contained seventeen compartments holding buoyant hydrogen gas bags, measured 416 feet long, 38 feet across, cubed 400,000 cubic feet, weighed nine tons, and had a displacement of ten tons.

Rapid progress has been made during the past decade in dirigible construction. The Zeppelin craft have been growing steadily larger in size and power and carrying capacity. The latest Zeppelins have a length of close on to 700 feet and a cubic capacity of well over two million cubic feet of gas. Seven engines and six propellers drive the Zeppelins of today. The British rigid dirigibles are closely patterned after the German Zeppelins, and the British R-34 was to all intents and purposes a Zeppelin.

How Man Grew His Wings

The fundamental theory of the airplane was set forth by an Englishman, Sir George Cayley, as early as 1809, and actually furnished the basis upon which the modern flying machine was subsequently built. In 1846 another Englishman, Stringfellow, gave a practical proof of this theory by building a small airplane model driven by a steam engine, which made several successful flights under perfect balance; this machine was, in conformity with Cayley's theory, a monoplane. In 1866 F. S. Wenham, also of England, invented the multiple-surfaced airplane and it was again Stringfellow who vindicated the claims of the new principle by a successful free flight of a triplane model. Further important contributions to the dynamics of the airplane were made by A. Penaud, H. Phillips, Sir Hiram Maxim, and S. P. Langley. The latter, an American and secretary of the Smithsonian Institution, built in 1903 a man-lifting monoplane which, but for its defective launching device, would have flown.

It is pretty generally admitted that the first airplane to have actually left the

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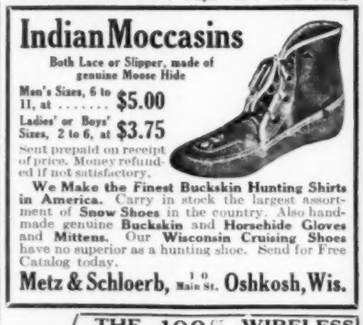
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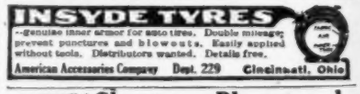
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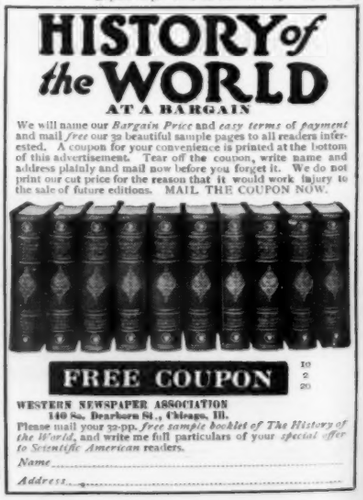
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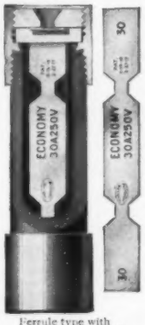

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ground, carrying a man, was the bat-shaped machine fitted with a 20-horsepower steam engine with which C. Ader, of France, made several short flights from 1890 to 1896. The balance of this machine, however, was poor, and it was only after the German, O. Lilienthal, had discovered by prolonged gliding experiments the means of controlling the balance of flying machines that progress became practical. Lilienthal's gliding experiments were repeated and perfected in this country, under the guidance of O. Chanute, by the Wright brothers of Dayton, Ohio. These brothers gave the airplane its one missing link, the warping mechanism for insuring transverse equilibrium; and having thus brought the dynamic flier under three-dimensional control, the Wright brothers fitted their glider with a gasoline engine driving twin propellers and succeeded in making their first power flights on December 17th, 1903, on the beach at Kitty Hawk, N. C.

The first float seaplane that left the water under its own power and returned thereto was built by Henri Fabre, of France, the trials taking place on March 28th, 1910, near Marseilles. Thence the development of the seaplane was chiefly due to the persistent efforts of Glenn H. Curtiss, of Hammondsport, N. Y., who produced the first practical float seaplane in 1911 and developed the following year, simultaneously with M. Denhaut, of France, the boat seaplane, or flying boat.

Particular credit for having advanced the mechanics of the airplane is due to Louis Bleriot and Edouard Nieuport, in monoplane construction; to Louis Breguet and A. V. Roe, for the development of the tractor biplane; to Gustave Eiffel, whose aero-dynamical research work placed airplane construction upon an engineering basis; to the Seguin brothers, for the invention of the rotary airplane engine, which has furthered the progress of aviation probably more than any other single development; and to Louis Chauviere, the inventor of the laminated wood propeller. With the exception of A. V. Roe, an Englishman, all these pioneers were Frenchmen. To their number may be added the Russian, Igor Sikorsky, who first built an airplane driven by several motors and thus proved the soundness of multi-engined power plants. Indeed, Sikorsky deserves unstinted praise for his foresight, and his machines were by far the forerunners of our present giant airplanes.

What the Airplane Owes to the Great War

So thoroughly did the airplane prove its military worth on the battlefields of Europe that all possible efforts and facilities were concentrated on the development of the airplanes of the belligerents. The airplane was improved by leaps and bounds.

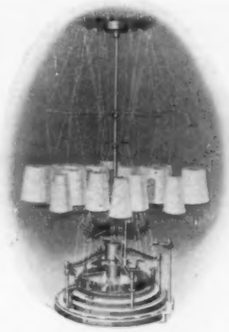
American aviation, which was at a very low ebb at the beginning of 1917, rose rapidly after our entry into the war. Once we got down to the business of producing airplanes and engines capable of competing with the best flying over the battlefields of France, we soon learned that other nations had little to teach us.

And we must not forget that the war made aviators by the tens of thousands. Until 1914 an aviator was a rare person; it was a great distinction to hold a pilot's license; few persons had gone aloft in airplanes. But with the call for fighting aviators, the various countries engaged trained thousands of young men for flying duty.

The past two years have seen the crossing of the Atlantic by airplanes, a flight from England to Australia as well as a flight from Rome to Tokyo, a flight from Mineola to Alaska, and other commendable achievements which would have been considered wild and even mad attempts but a few years ago.

The closing months of the period reviewed in this brief résumé of flying progress have been marked by the ap-

Knitting Mills — Cotton Mills



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pearance of the all-metal machine in peaceful pursuits. It was during the last year of the war that Germany introduced all-metal airplanes over the battlefields of France, and those Junker monoplanes were erroneously looked upon as mere freaks not worth even copying for experimental purposes. As a result the German aircraft constructors have scored a distinct scoop, to use the parlance of the newspaperman, on the world at large. Since the war the Germans have adapted their Junker monoplane to commercial work, and as such they have a most excellent six- or eight-passenger machine which has scored many enviable records. The metal airplane, which marks a new era in airplane construction, was predicted in the SCIENTIFIC AMERICAN as early as 1910, together with the retractible chassis, gyroscopic stabilizer, and other features now realized in present machines.

Seventy-five Years of American Patent Administration

(Continued from page 341)

efficiency. It is appropriate that the Patent Office should have been the scene of this innovation, for nowhere else in the Government service is the character of the personnel such a vital factor in the value of its proceedings. If Commissioner Fisher demonstrated nothing eles than the efficiency and morality of the merit system, his administration would have been among the most notable. And yet this was but one of several similarly vital reforms he introduced.

Congressional Recognition

Frequently, an executive's hands are tied by the law. Do all he can, turn as he will, progress may be denied him owing to conditions imposed by statute. Having done all within a man's power to improve the administration of the office, but recognizing the legal limitations that barred proper development, Commissioner Fisher next attempted to overcome the inertia of the law-making body. New legislation was absolutely essential for carrying into effect his ideas as gained from his experiences, and he did not hesitate to ask for everything that he deemed necessary for that purpose.

In the first place, Mr. Fisher proposed legislation which led to the publication of the *Official Gazette* and the photolithographing of copies of patents. He was also instrumental in placing on the statute book, with the powerful aid of Representative Jenckes, the consolidated patent act of 1870. This act codified the law and, in addition, presented new features tending in the direction of modernization.

The patent act of 1870 not only introduced several broadly new features but codified the laws relating to patents, and the office is now running substantially on the basis of that act. The most important innovation since that time was the creation in 1883 of the International Bureau for the Protection of Industrial Property, by which the residents of every subsidiary country have reciprocal rights in all the other countries in regard to applying for patents and the procedure connected therewith in the respective patent offices.

The Patent Office and the Courts

Another change of momentous influence was the modification of the jurisdiction of the United States Supreme Court. Up to 1891, the highest court of the land assumed appellate jurisdiction in patent causes. Since that time, except in highly specialized instances, the courts of last resort in patent litigation are the nine separate circuit courts of appeal. There has resulted from this change, made necessary to relieve the docket of the United States Supreme Court, a confusion of principles, an uncertainty in patent rights and an inconsistency between the frequently inharmonious views of the different but equally important jurisdictions.

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IF YOU HAVE AN INVENTION which you wish to patent you can write fully and freely to Munn & Co. for advice in regard to the best way of obtaining protection. Please send sketches or a model of your invention and a description of the device, explaining its operation.

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SCIENTIFIC AMERICAN

contains Patent Office Notes. Decisions of interest to inventors—and particulars of recently patented inventions.

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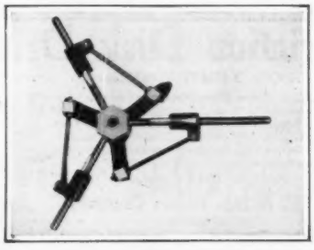

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But the greatest loss has been in the absence of those great decisions formerly handed down from the Supreme Court bench.

The patent system established by the act of 1836, creating the so-called "American" or "examination" method of granting patents by which scientifically and legally trained men scrutinized the technical merits of the invention, compared it with all known like efforts by an examination of every available printed record, and determined the form and legal limitations of the grant, has been pronounced to be the greatest piece of constructive legislation ever placed on our statute books. Certainly, no law designed for purely national aims has ever been copied so extensively as this. Almost every nation which has any pretension to being influenced by modern industrial tendencies, has adopted it or adapted it to its own purposes. This law thrust upon the Patent Office a substantial portion of the legal work that had hitherto devolved upon the courts. It was a radical departure from all existing systems, which merely provided for the "registration" of the application when deposited in the Patent Office, and gave the patent neither legal nor industrial value.

Under the registration system, patents were granted to others than the inventors, or for inventions that were old or inoperative. This system was tried out for 33 years previous to 1836, and created such uncertainty in the patent situation, opened the door to so many frauds, and was productive of so much unnecessary litigation, that it became more of a menace to industry than a help, and depressed the spirit of invention rather than stimulated it. England, as already stated, discarded this system.

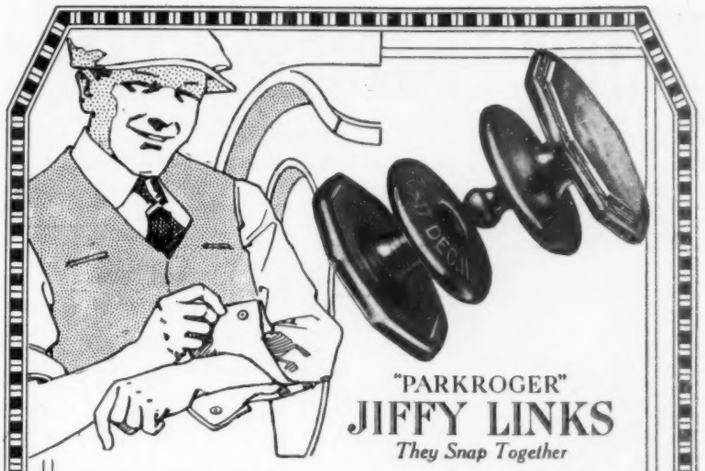
Germany and Japan, the two countries above all others in recent times which have had their eyes open to the main chance, have copied the American or "examination" patent system. No other nations ever made such conscious, deliberate and studied attempts to achieve material success, and they went to every other country to learn what it most had to offer, and did not hesitate to borrow and adopt from it what they found most of value.

Our Patent Growth

America is the land of ingenuity, and the national genius finds its outlet in invention. As far back as 1857, the applications filed in the U. S. Patent Office exceeded those filed in England by one-third, and since the founding of this government, almost as many patents were granted in the United States as in England, France and Germany combined. The measure of the activity, however, of the Patent Office is indicated by the applications filed, and not by the patents granted. It is curious to observe in this respect how the history of the great war repeats the experience of the Civil War. The heaviest year in applications filed preceding the latter event was in 1860. In 1861 occurred a decided dropping off, succeeded by gradual gains in the following years. In 1864, with the end of the war in sight, a marked increase took place, while in the three succeeding years the business jumped by leaps and bounds.

So in the more recent event—the year 1916 saw the largest business ever presented to the office up to that time. Our entrance into the war did not make itself felt until several months later, but in 1918 its full effect was shown in a 15 per cent drop in receipts from the average of the seven preceding years. Before the year 1919 got well under way, the effect of the cessation of hostilities became apparent, and by summer the receipts began to exceed those of the heaviest of preceding years.

The intimate association between industrial progress and inventions is shown in the history of two inventions developed during the life-time of the average college boy. The automobile and the moving pic-



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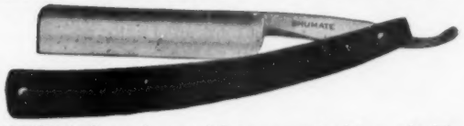

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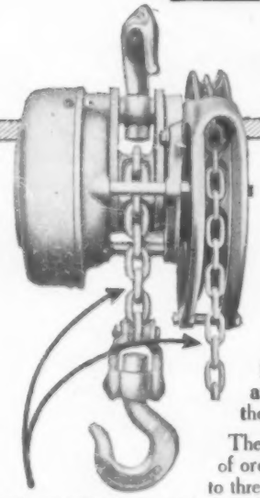

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ture were merely experimental features at the beginning of the century. Today, the film picturizations directly and indirectly involve capital employment going into the billions, while the annual output of automobile and accessory producers aggregates the amazing figure of three and one quarter billions of dollars, which is more than three times as much as the total aggregate of *all* production in this country in 1850, when we had a population of 23,191,876. The automobile has jumped Detroit in ten years from a city of the third class to one in the first class, while the "movie" has made Los Angeles a near-metropolis and given it international renown. The difference between countries influenced by invention on the one hand, and removed from its effects on the other is strikingly shown in a comparison in material welfare between United States and Russia.

The Diamond Jubilee of the Scientific American

(*Continued from page 343*)

stitution of a carbon paper ribbon. Compliments from our subscribers came from all over the world; for when once in typewritten form there was no difficulty in transferring the matter lithographically and printing in the "offset" presses.

The Scientific American Monthly

In 1876 the Centennial Exhibition offered such an alluring field, with its vast stores of information, that it was decided to publish the SCIENTIFIC AMERICAN SUPPLEMENT. When the Exposition closed the SUPPLEMENT was too well liked by the subscribers for the publishers to abandon it. Tihs popularity remained with the successive volumes until it was decided to bring it out in monthly form, beginning January 1, 1920, under the name SCIENTIFIC AMERICAN MONTHLY.

In the few months which have elapsed the MONTHLY has proved its worth, and is conceded to be the best scientific periodical of its type in the world.

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The business homes of Munn & Co. and the SCIENTIFIC AMERICAN in New York have been few in number.

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Messrs. Munn & Co. have their own building in Washington, adjacent to the Patent Office, so that the business of their clients can be expeditiously handled. Branch offices are also maintained in Chicago and San Francisco.

It is very seldom in this country that a business enterprise remains in the same family for a period of nearly 75 years. It seems appropriate, therefore, to commemorate the event in a becoming manner. The son of one of the original founders is president of the present organization and his grandson, its treasurer.

From Wet Plate to Motion Pictures

(*Continued from page 346*)

when exposed to light in combination with bichromate of potash. This observation was first made by Becquerel. The next idea evolved was that gelatine made insoluble by light might be made to imprison particles of coloring matter. Where light acted, these would remain; where it did not act they would wash out by reason of the insolubility of the portion of the films in which they were contained. This was an important step and was made by Poitevin in 1855. The carbon process now used was invented and patented in 1866 by J. S. Swan.

When the Dry Plates Replaced the Wet Plates

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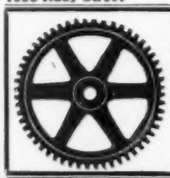

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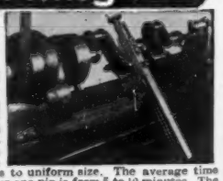

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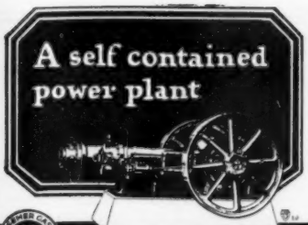

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in England, and J. M. Taupenot seems to have been the first to have invented a practical dry plate. His process was cumbrous. It was not until Major C. Russell introduced the alkaline developer in 1862, which necessitated the employment of silver bromide on the sensitized glass, that the dry plate really became workable by anyone. His dry plates were the forerunner of those we now employ.

Up to the time of W. B. Bolton and B. J. Sayre's experiments in 1864, silver iodide had been considered the staple of a sensitized film on which to take negatives. It occurred to them to bring the sensitive salts of silver in collodion while liquid and to form a sensitive film merely by letting the collodion, containing the salts in suspension, flow over the glass plate. Thus the collodion emulsion process was born—a process which revolutionized photographic manipulations. M. Carey Lea and W. Cooper, Jr., placed the process on a commercial basis by improvements which made the plate more sensitive.

Since silver bromide emulsion could not be prepared in collodion, naturally experimeters began to cast about for collodion substitutes. The researches of Madox, King, Burgess, but above all the work of R. Kennett and C. Bennett, from 1871 to 1878, resulted in the gelative emulsion process of making dry plates.

The Rise of the Film Camera

Dry plates were too heavy and cumbrous for the amateur. A thin, rollable, continuous, transparent strip, which would carry the negative, was required. That need was supplied by the celluloid film which was invented by the Rev. Hannibal Goodwin in 1887. There can be no doubt that the celluloid film was also independently worked out by Eastman and his chemists; certainly the commercial film came from George Eastman and his associates.

Eastman has contributed more to present-day photography than any other worker in this field. He followed up the commercializing of film negative by developing the handy camera which he called the "Kodak." The first camera of this vast camera family appeared in 1888. It took round pictures, 2½ inches in diameter, had a fixed focus, and carried a roll of 100 exposures. Compared with the cameras of today, it was crude, to be sure; but in its time it marked a vast stride forward and started the true era of amateur photography. Later Eastman made his film cartridge light-proof, thus introducing the daylight-loading feature.

Year after year film cameras, as well as hand cameras in general, have been improved and refined. It is only a few years ago that cameras were generally fitted with simple double lenses of the rapid rectilinear type in place of the simple, meniscus lenses of an earlier period. Today practically every camera intended for anything like good work is provided with anastigmat lenses.

Again, it is only a few years ago that the autographic feature was made part of the kodaks, marking another big step in making the camera a useful article rather than a chance sport.

Space does not permit us to delve into the interesting subject of color photography, which, strange to say, is a phase of long standing. Suffice it to mention that color photography has received the attention of a host of inventors and experimenters, but even today it does not seem to have developed to a simple enough stage to warrant its universal application.

Pioneer Days of Motion Pictures

It was the invention of celluloid film that made motion pictures possible on a commercial scale. Prior to the introduction of film there were numerous attempts at motion pictures, beginning with Dr. Coleman Sellers of Philadelphia, who took out a patent in February, 1861, for what he called a "stereoscopic cabinet," but which came to be known as the "kinemat-

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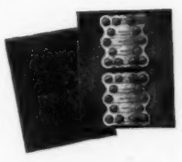
And in your plant every stop of their thundering means production lost, power lost and dollars lost forever.
Belts which fail because joined so their strength is impaired are a source of avoidable loss.



This is the scientific method of joining belts to maintain their maximum strength. Crescent Belt Fasteners hold—without holes. Joint runs same as endless, without noise and without strain. No metal contacts with pulleys to wear or crystallize. Joint is permanent for life of belt, yet provides easy and economical take up of slack. Write for details.

CRESCENT BELT FASTENERS
Make Good Belts Give Better Service

Permitting anything short of maximum belt life, or rejoining it while men and machines stand idle costs you power, labor, time, investment and production. Stop it. Make it creative!
Crescent Belt Fasteners standardized throughout your plant will maintain continuous production, and your belts will give better service and serve their longest life.
Write for full details in Booklet "B" on Modern Scientific Methods in Belt Joining.

CRESCENT BELT FASTENER CO.
381 Fourth Avenue, New York City
Canadian Office, 32 Front St., West, Toronto, Canada.
Birmingham, England, 32 Paradise Street

A Recent GTD Advertisement

They produce a bushel of wheat in 8 minutes

IN 1830, says Barton W. Currie, human labor produced a bushel of wheat in an average of three hours and three minutes. Today with the aid of machines, we produce that same bushel in 8 minutes.

Quantity production is not only a matter of shops and factories, but of the grain fields where real miracles are being wrought by implements, tractors, trucks, appliances.

Improved farm machinery results from the work of modern thread-cutting tools which produce the nuts, bolts, rods and tapped holes that hold most machines together, and for production or repair of farm machinery, GTD taps, dies, reamers and gages are essential.

When next you see a tractor, reaper or simple ensilage-cutter at its work, think of the hidden threaded parts that make it possible. Then think of the GTD tools that made the threaded parts possible.

To executives, engineers and designers, who seek to produce in greater quantities, products on which they are working, GTD offers a profitable service. Send the coupon or a letter under your personal signature for "Tools and Dividends," the book of threading knowledge, especially prepared for those interested.

Little Giant Screw Plate

GTD
Corporation
Greenfield
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Without obligation send your booklet "Tools and Dividends." I am interested in examining screw-thread production for

Name of company

Name of writer

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GREENFIELD TAP AND DIE CORPORATION
GREENFIELD, MASSACHUSETTS

Canadian Plant: Greenfield Tap & Die Corporation of Canada, Limited, Galt, Ont.

MONARCH LATHES

Monarch supremacy has been gained by the building of an honest lathe that delivers service satisfactory to the purchaser.

And bearing the guarantee "Satisfaction To the Purchaser" there are more lathes produced and sold each year by the Monarch organization than there are lathes built by any other High Grade Lathe Manufacturer. Specify Monarch Lathes.

Write for catalog

The Monarch Machine Tool Co.
Sidney Ohio

IT was Sir Samuel Cunard and his associate founders of the Cunard Line who really gave the first impetus to systematic transatlantic travel, eliminating its discomforts and making ocean travel an allurement to countless thousands who now speed upon their way of business or enjoyment with a feeling of comfort and luxury.

The extended intercourse and greater intimacy between the old and the new world which have naturally resulted from increased facilities in ocean travel contribute greatly to cementing those cordial relations between America and England which mean so much in both nations' progress.

For eighty years, extending over a period of four generations, Cunard liners have enjoyed the unquestioned favor of American ocean travellers, a favor which we cherish and aim to retain.

CUNARD-ANCHOR

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oscope." Because he introduced the intermittently moved ribbon-like picture carrier, Sellers is in a sense the father of motion-picture photography. Others who worked on the motion picture were Donisthorpe in 1878, Marey in 1881, and Reynaud in 1889. While all of these adopted and employed perforated picture ribbons, Marey employed the celluloid film.

The intricacies and conveniences of the camera naturally depended on the kind of plate being used. In the camera used by Niepce and Daguerre, the focusing was accomplished by sliding the lens back and forth. Daguerre, in 1839, focused his camera by having one section sliding in or out of the other. Then followed the camera with stationary front and the back sliding upon its base with a set-screw and connected with the front by means of a bellows. It remained for the American inventor, George Eastman, to simplify and refine the camera and accessories of those days so as to make amateur photography what it is today.

Credit for giving the first exhibition of motion pictures goes to Henry Heyl of Philadelphia. In 1870, Heyl exhibited his "Phasmatrope" before an audience of over 1,500 persons. The related photographs were small glass positives of selected subjects reduced from wet plate negatives, taken from successive poses, by an ordinary camera.

Then there is the work of Edward Muybridge, whose horse-galloping pictures made him famous. His remarkable studies of animals in motion were made with a battery of cameras. His work was more scientific than of commercial value. Muybridge did design, about 1880, his "zoopraxiscope" to exhibit his glass plate positives of animal movements. This was similar to Heyl's work.

In 1889 Edison made his first motion-picture camera in which the film was intermittently moved. His earliest form of exhibiting apparatus, known as the "kinetoscope," was a machine in which a positive print from the negative obtained in the camera was exhibited directly to the eye through a peephole. In 1895 the films were applied to modified forms of magic lanterns and the images projected on the screen.

Another pioneer in the motion-picture field was C. Francis Jenkins of Washington, D. C. In 1893 and again in 1894 this inventor exhibited a projector which, in its essentials, was practically a modern projector. Again Lumiere gave the first public demonstration in Paris in 1895, with his kinematograph—a combination camera-projector which exhibited pictures of remarkable beauty.

And there are scores of other workers, each contributing something to the development of motion-picture photography. And all these efforts finally resolved themselves into a standard sized film which today is in universal use. The equipment, too, has been standardized. Indeed, no industry of such magnitude can boast of more complete standardization, which feature has gone far to make the motion picture a commercial and universal success of the first magnitude.

There have been motion pictures in colors. Many attempts have been made to add color to the screen, and many of these have attained no mean degree of success. Today several methods of obtaining natural color effects are in use. It has been said by one school of the art that color pictures will rule supreme within a few years; and it has been said by an equally emphatic school that black-and-white pictures are here to stay, and will never be ousted by color pictures.

Again, there have been talking pictures, but these have not met with much success from a commercial standpoint. The main difficulty in this direction is that the technical development has not advanced to a satisfactory point. And even allowing technical success, the fact remains that the present films can get along without sound.

$5,000 Prize Essay

The Einstein Theory of Relativity

Mr. Eugene Higgins offers through the SCIENTIFIC AMERICAN a prize of $5,000 for the best essay on the Einstein theories so written that it may be read with profit by an ordinarily intelligent person with no special mathematical training. The competition is open to any person, without restrictions of any sort, subject to the following

CONDITIONS:

1. No essays shall be longer than 3;000 words.

2. All essays must be in English, and written as simply, lucidly and non-technically as possible.

3. Each essay must be typewritten, and identified with a pseudonym. The essay shall bear a title and the author's pseudonym *only*, and must be enclosed in a plain sealed envelope likewise bearing this pseudonym. In the same package with the essay must be sent a second plain sealed envelope, also labelled with the pseudonym, and containing a statement of the name and address of the contestant, the pseudonym used, and the title of the essay. It is necessary to follow these instructions implicitly, in order to guard against confusion in opening the envelopes and assigning the pseudonyms to their proprietors, especially in view of the possibility that two of the contestants may employ the same pseudonym. The envelopes should be sent in a single package to the Einstein Prize Essay Editor, SCIENTIFIC AMERICAN, 233 Broadway, New York.

4. All essays must be in the office of the SCIENTIFIC AMERICAN by November 1st, 1920.

5. The Editor of the SCIENTIFIC AMERICAN will retain the small sealed envelopes containing the competitors' names and addresses, which will not be opened until the competitive essays have been passed upon and the winning essay selected.

6. As soon as the judges have selected the winning essay, they will notify the Editor, who will open the envelope bearing the proper pseudonym and revealing the competitor's true name. The competitor will at once be notified that he has won, and his essay will be published in an early issue of the SCIENTIFIC AMERICAN.

7. There shall be but one prize, of FIVE THOUSAND DOLLARS, to go to the author of the best essay submitted.

8. The SCIENTIFIC AMERICAN reserves the right to publish in its columns, or in those of the SCIENTIFIC AMERICAN MONTHLY, or in book form, any of the essays which may be deemed worthy of this. Aside from such rights, the essays shall remain the properties of their authors; but no manuscripts can be returned.

9. The Committee of Judges will consist of Professors Leigh Page of Yale and E. P. Adams of Princeton. In the event that they are unable to agree on the best essay, the Einstein Prize Editor will cast the deciding vote.

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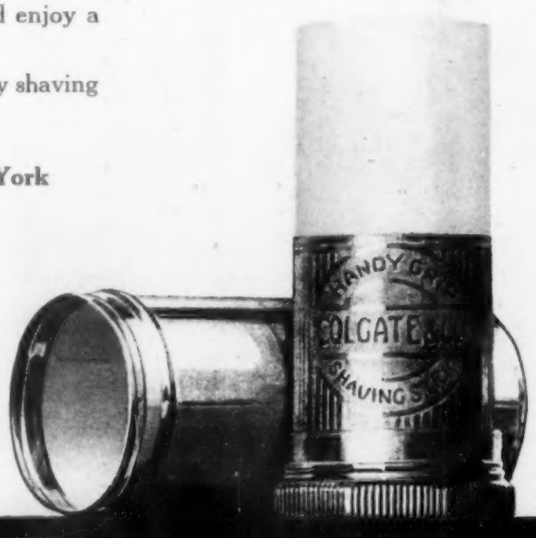

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